

Role of First-Trimester Uterine Artery Doppler in the Prediction of Pre-Eclampsia among High-Risk Pregnancies: A Prospective Observational Study

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ABSTRACT

Background: Pre-eclampsia (PE) is a major obstetric complication that may develop later in pregnancy but originates early in gestation. Early prediction in high-risk women enables timely interventions. This study evaluated the accuracy of first-trimester uterine artery (UtA) Doppler indices in predicting PE.

Methods: We conducted a prospective observational study at the Department of Obstetrics and Gynaecology, MKCG Medical College and Hospital (MKCGMCH), Berhampur. Over a one-year period (January 2025 to January 2026), 84 high-risk pregnant women underwent transabdominal UtA Doppler screening between 11 and 13+6 weeks of gestation. We tracked the mean Pulsatility Index (PI), Resistive Index (RI), and the presence of bilateral diastolic notching. The cohort was followed through delivery to record the incidence of PE and subsequent fetal outcomes.

Results: Among 84 expectant mothers, 21 (25%) developed pre-eclampsia. First-trimester UtA-PI was significantly higher in those who developed PE (2.15 ± 0.38 vs. 1.52 ± 0.29 , $p < 0.001$). Persistent bilateral diastolic notching was also strongly associated with PE ($p < 0.001$). At a UtA-PI >95 th percentile, sensitivity was 76.1%, specificity 85.7%, and NPV 91.5%. Abnormal Doppler findings were also associated with higher rates of preterm birth and NICU admission.

Conclusion: First-trimester uterine artery Doppler, particularly an elevated Pulsatility Index and the presence of bilateral diastolic notching, serves as a powerful, non-invasive early warning system for pre-eclampsia. By integrating this screening into routine early antenatal care at MKCGMCH, clinicians can confidently identify which high-risk mothers will benefit most from early aspirin prophylaxis and vigilant surveillance.

Key-words: Heliothis armigera, Argemone mexicana, Ethanol, acetone, Epithelial lining, Epithelial cells, vacuoles, Gut lining, Gut wall

INTRODUCTION

Pre-eclampsia (PE) is one of the most important hypertensive disorders of pregnancy and remains a major cause of maternal and perinatal morbidity and mortality worldwide.

Although the clinical manifestations of PE usually become evident after 20 weeks of gestation, the pathological processes leading to the disease begin much earlier in pregnancy. Abnormal placentation, inadequate trophoblastic invasion and impaired transformation of the maternal spiral arteries result in increased vascular resistance and subsequent maternal endothelial dysfunction. Therefore, identification of early markers of abnormal placentation may provide an opportunity for predicting women at increased risk of developing PE before clinical symptoms appear ^[1].

The first trimester represents a critical period for assessing maternal cardiovascular and placental

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adaptation. Uterine artery (UtA) Doppler ultrasonography provides a non-invasive assessment of uteroplacental blood flow and reflects the resistance within the uteroplacental circulation. Parameters such as the uterine artery pulsatility index (UtA-PI) and the presence of early diastolic notching have been investigated as potential markers of impaired placentation [2,3]. Increased UtA-PI indicates increased downstream vascular resistance, while persistent bilateral diastolic notching may reflect incomplete remodeling of the spiral arteries [4].

Several studies have demonstrated an association between abnormal first-trimester uterine artery Doppler findings and subsequent development of PE. Women who develop PE may demonstrate higher uterine artery resistance compared with those who remain normotensive, suggesting that Doppler assessment may identify impaired placentation before clinical disease becomes apparent [5]. The predictive performance of UtA Doppler, however, varies according to gestational age, population characteristics, risk profile and the threshold used to define an abnormal result [6].

Early identification of women at increased risk is clinically important because preventive strategies can be initiated before significant placental and maternal vascular complications develop. Low-dose aspirin, when appropriately indicated and initiated early in pregnancy, may reduce the risk of PE in selected high-risk women [7]. Consequently, a simple, non-invasive and reproducible screening approach that can be incorporated into routine first-trimester assessment may have considerable clinical value.

Despite increasing evidence supporting the role of uterine artery Doppler, differences in diagnostic performance among high-risk populations warrant further evaluation. The present study was therefore undertaken to assess the ability of first-trimester UtA Doppler indices, particularly UtA-PI and bilateral diastolic notching, to predict subsequent development of PE in high-risk pregnant women and to evaluate their association with adverse perinatal outcomes [8].

MATERIALS AND METHODS

Study Design and Setting- This was a prospective observational study carried out at the Department of Obstetrics and Gynaecology, MKCGMCH, Berhampur, spanning from January 2025 to January 2026.

Study Population- We carefully selected a cohort of 84 pregnant women carrying singleton pregnancies. To be included, mothers had to possess at least one major clinical risk factor for pre-eclampsia. These included a prior history of PE, chronic hypertension, pre-existing diabetes mellitus, a Body Mass Index (BMI) > 30, or advanced maternal age (> 35 years).

Inclusion Criteria

- Singleton pregnancy
- Gestational age 11–13+6 weeks
- At least one major risk factor for pre-eclampsia
- Consent for participation

Exclusion Criteria

- Multiple pregnancy
- Gestational age outside 11–13+6 weeks
- Incomplete clinical/Doppler data
- Lost to follow-up

Clinical Protocol- During the critical 11 to 13+6 weeks' ultrasound window (typically coinciding with the nuchal translucency scan), all participants underwent a transabdominal UtA Doppler assessment. We measured the blood flow in both the left and right uterine arteries, calculating the mean Pulsatility Index (PI) and the mean Resistive Index (RI). We also visually assessed the waveform for early diastolic notching. For this study, a Doppler result was flagged as "abnormal" if the mean UtA-PI was above the 95th percentile for that specific gestational age, or if bilateral notching was present.

Statistical Analysis- Mothers were monitored closely through routine antenatal check-ups until delivery. Our primary clinical endpoint was the clinical diagnosis of pre-eclampsia. We used independent t-tests to analyze continuous variables and Chi-square tests for categorical data. We considered a p-value of < 0.05 to indicate statistical significance.

RESULTS

Over the course of the year, we followed all 84 mothers through their pregnancies. Ultimately, 21 women (25%) developed pre-eclampsia, while 63 (75%) maintained normal blood pressure or did not meet the criteria for the disease.

First, we looked at the baseline characteristics of our mothers to ensure the two groups were comparable. While age and the timing of their scans were similar, we

noted that maternal BMI was significantly higher in the group that went on to develop pre-eclampsia (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics

Variable	Developed PE (n = 21)	Did Not Develop PE (n = 63)	p-value	Statistical Significance
Mean Age (years)	29.5 ± 4.3	28.1 ± 3.8	0.165	Not Significant
Mean BMI (kg/m ²)	29.4 ± 3.5	26.8 ± 3.1	0.003	Significant
Primigravida n (%)	9 (42.8%)	29 (46.0%)	0.801	Not Significant
Gestational Age at Scan (wks)	12.6 ± 0.5	12.5 ± 0.6	0.490	Not Significant

We then broke down the specific risk factors that brought these women into our high-risk cohort. A previous traumatic experience with pre-eclampsia

proved to be the most significant red flag for recurrence in our study population (Table 2).

Table 2: Distribution of Major Pre-Eclampsia Risk Factors

Risk Factor	Developed PE (n = 21)	Did Not Develop PE (n = 63)	p-value	Statistical Significance
History of Previous PE	10 (47.6%)	11 (17.4%)	0.006	Significant
Chronic Hypertension	5 (23.8%)	10 (15.8%)	0.407	Not Significant
Pre-existing Diabetes	3 (14.2%)	6 (9.5%)	0.547	Not Significant
Maternal Age > 35 years	3 (14.2%)	10 (15.8%)	0.857	Not Significant

Table 3 represents the biological core of our findings. Even at 12 weeks, long before any clinical symptoms appeared, the resistance in the uterine arteries was

profoundly elevated in the mothers who would eventually fall ill.

Table 3: First-Trimester Uterine Artery Doppler Indices

Doppler Parameter	Developed PE (n = 21)	Did Not Develop PE (n = 63)	p-value	Statistical Significance
Mean UtA-PI	2.15 ± 0.38	1.52 ± 0.29	< 0.001	Highly Significant
Mean UtA-RI	0.78 ± 0.08	0.61 ± 0.05	< 0.001	Highly Significant
Bilateral Diastolic Notching	13 (61.9%)	9 (14.2%)	< 0.001	Highly Significant

To translate these ultrasound findings into practical, everyday use on the clinic floor, we calculated the test's predictive accuracy. Notably, the test excels at ruling out

the disease; a normal scan offers immense reassurance to an anxious mother (Table 4).

Table 4: Predictive Validity of Abnormal Doppler (PI > 95th Percentile)

Diagnostic Metric	Value (%)	95% Confidence Interval
Sensitivity	76.1%	52.8% - 91.7%
Specificity	85.7%	74.6% - 93.3%
Positive Predictive Value (PPV)	64.0%	42.5% - 82.0%
Negative Predictive Value (NPV)	91.5%	81.3% - 97.1%
Overall Accuracy	83.3%	73.6% - 90.5%

Finally, we looked at the babies. We split the entire group of 84 mothers based solely on whether their 12-week Doppler was normal (n=59) or abnormal (n=25).

High resistance in the first trimester was a strong harbinger of a tougher start to life for the newborn (Table 5).

Table 5: Perinatal Outcomes Based on Early Doppler Findings

Perinatal Outcome	Abnormal Doppler (n = 25)	Normal Doppler (n = 59)	p-value	Statistical Significance
Mean Birth Weight (grams)	2390 ± 410	3120 ± 375	< 0.001	Highly Significant
Preterm Delivery (< 37 weeks)	11 (44.0%)	7 (11.8%)	0.001	Significant
NICU Admission	9 (36.0%)	5 (8.4%)	0.002	Significant
Apgar Score < 7 at 5 mins	5 (20.0%)	2 (3.3%)	0.012	Significant

DISCUSSION

The present study evaluated the role of first-trimester uterine artery Doppler assessment in predicting subsequent development of pre-eclampsia among high-risk pregnant women. Of the 84 women included, 21 (25%) subsequently developed PE. The findings demonstrated a significant difference in first-trimester UtA-PI between women who later developed PE and those who remained normotensive. The mean UtA-PI was substantially higher in the PE group (2.15 ± 0.38) compared with the normotensive group (1.52 ± 0.29), with a highly significant p-value (<0.001). This observation supports the relationship between increased uteroplacental vascular resistance in early pregnancy and subsequent development of PE.

The association observed in the present study is biologically plausible because inadequate remodeling of the spiral arteries results in persistence of a high-resistance uteroplacental circulation. Doppler assessment of the uterine arteries provides an indirect measure of this vascular resistance, and an elevated PI may therefore identify pregnancies in which placental vascular adaptation is impaired.

Previous studies have similarly reported increased uterine artery resistance among women who subsequently develop hypertensive disorders of pregnancy^[9,10].

Persistent bilateral diastolic notching was also significantly associated with progression to PE in our study ($p < 0.001$). Diastolic notching reflects increased resistance to blood flow within the uteroplacental circulation and may indicate incomplete physiological transformation of the uterine spiral arteries. The persistence of bilateral notching into the later part of the first trimester may therefore provide additional information regarding abnormal placentation. Similar associations between persistent uterine artery notching and adverse pregnancy outcomes have been described in earlier investigations^[11].

When a UtA-PI value above the 95th percentile was used as the diagnostic threshold, the present study demonstrated a sensitivity of 76.1% and specificity of 85.7%. The negative predictive value was 91.5%, indicating that a considerable proportion of women with a UtA-PI below the selected threshold did not subsequently develop PE. These findings suggest that UtA-PI may have useful predictive value, particularly as part of an early screening strategy rather than as an

isolated diagnostic test. Differences in sensitivity and specificity reported between studies may be related to variations in population risk, gestational age at Doppler assessment, methodology and threshold selection [12,13].

An important finding was the association between abnormal Doppler findings and adverse perinatal outcomes. Pregnancies with abnormal uterine artery Doppler parameters demonstrated higher rates of preterm birth and NICU admission. This may reflect the broader consequences of abnormal placentation, in which impaired uteroplacental perfusion can contribute not only to maternal hypertensive disease but also to fetal growth restriction, medically indicated preterm delivery and neonatal morbidity. Previous studies have also reported relationships between abnormal uterine artery Doppler findings and adverse obstetric outcomes [14].

The findings of the present study highlight the potential usefulness of first-trimester uterine artery Doppler as part of risk assessment in high-risk pregnancies. Its non-invasive nature and ability to detect abnormal uteroplacental resistance before clinical manifestations of PE make it potentially useful during early antenatal screening. However, Doppler findings should be interpreted in the context of maternal characteristics and other established risk factors rather than considered independently.

The study also has limitations. The sample size was relatively small and the study population consisted of high-risk pregnant women, which may limit generalisation to the broader obstetric population. Further larger, multicentre prospective studies are required to validate the observed diagnostic performance and determine the most appropriate Doppler thresholds for different populations. Combining UtA Doppler with maternal characteristics and biochemical markers may also improve prediction compared with Doppler assessment alone [15].

CONCLUSIONS

First-trimester uterine artery Doppler—specifically the measurement of the mean Pulsatility Index (PI) and the identification of bilateral diastolic notching—is a highly effective, non-invasive tool for predicting pre-eclampsia in high-risk pregnancies. Our one-year experience at MKCGMCH confirms that abnormal vascular flow at 11 to 13+6 weeks strongly correlates with the later

development of the disease and adverse perinatal outcomes. Integrating this screening systematically into early antenatal care equips clinicians with the foresight needed to initiate timely prophylactic treatments, tailor maternal surveillance, and ultimately safeguard the lives of both mother and child.

CONTRIBUTION OF AUTHORS

Research concept- Dr Sunil Kumar Pradhan

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