



Role of first-trimester uterine artery Doppler in predicting preeclampsia

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Abstract: **Background:** Preeclampsia is a major cause of maternal and perinatal morbidity and mortality, particularly in low-resource settings. **Objective:** To evaluate the role of first-trimester uterine artery Doppler in predicting preeclampsia. **Methods:** This prospective observational study was conducted at Department of Obs and Gyne DHQ Bhakkar from march 2024 to march 2025 and included 189 pregnant women between 11 and 14 weeks of gestation. Uterine artery Doppler ultrasonography was performed to measure pulsatility index (PI), resistance index (RI), and the presence of early diastolic notching. Abnormal Doppler findings were defined as mean PI above the 95th percentile and/or bilateral notching. **Results:** The mean age of participants was 27.9 ± 4.8 years. Abnormal uterine artery Doppler findings were observed in 25.4% of women. Preeclampsia developed in 18.0% of participants, including 6.3% with early-onset and 11.6% with late-onset disease. Women with abnormal Doppler findings had a significantly higher incidence of preeclampsia compared to those with normal findings (43.8% vs 9.2%, $p < 0.001$). The mean PI was significantly higher in women who developed preeclampsia (2.11 ± 0.38 vs 1.63 ± 0.42 , $p < 0.001$). Bilateral notching was more frequent in affected women (55.9% vs 7.7%, $p < 0.001$). The sensitivity, specificity, positive predictive value, and negative predictive value of uterine artery Doppler were 61.8%, 85.8%, 43.8%, and 90.8%, respectively. **Conclusion:** First-trimester uterine artery Doppler is an effective non-invasive tool for early prediction of preeclampsia, particularly for identifying high-risk pregnancies.

Keywords: Preeclampsia, Uterine artery Doppler, First trimester, Pulsatility index, Pregnancy, Screening



INTRODUCTION

Preeclampsia is a pregnancy-related hypertensive multisystem disorder with the development of new-onset hypertension and dysfunction of end-organ systems after 20 weeks of pregnancy [1]. It is a major cause of maternal and perinatal morbidity and mortality among women, irrespective of their countries of origin and location, especially in low- and middle-income countries with less access to timely antenatal care and early risk stratification [2]. This condition is linked to severe complications such as eclampsia, placental abruption, fetal growth restriction, and preterm birth, and early detection of high-risk pregnancies is therefore a major concern in obstetric care. Preeclampsia pathophysiology is complex and not entirely understood, but abnormal placentation is believed to be a leading mechanism [3]. During normal pregnancy, these vessels are invaded by trophoblasts, which remodel them into low-resistance, high-capacitance vessels to ensure sufficient uteroplacental blood flow. This remodelling process is not fully carried out in preeclampsia, which leads to the continued high-resistance uterine circulation, decreased placental perfusion, and a subsequent maternal endothelial dysfunction [4]. These hemodynamic alterations take place very early in pregnancy, in many cases long before the signs have become clinical, which offers a justification of an early screening approach [5].

Uterine artery Doppler ultrasonography has become a non-invasive technique for assessing uteroplacental blood flow and the presence of abnormal vascular resistance. During the first trimester, Doppler indices, including the pulsatility index (PI) and resistance index (RI), as well as the presence of early diastolic notching, may indicate poor trophoblastic invasion and elevated vascular resistance [6]. High uterine artery PI and continuous notching have been linked to the higher risk of developing preeclampsia, especially the earlier onset and more severe form of the disease. Thus, first-trimester uterine artery Doppler has the potential to predict early, before the clinical manifestations occur [7,8]. The clinical importance of early detection of women at high risk of preeclampsia is based on the fact that, by the time the high-risk women are identified, preventive measures against the illness can be taken, such as low-dose aspirin, which has been observed to lower the occurrence and severity of the disease when taken early in pregnancy [9]. In addition, risk stratification leads to enhanced monitoring, optimal antenatal care, and maternal and fetal outcomes. Although traditional risk assessment has predictive value, using it alone based on maternal history and clinical factors is not sufficiently sensitive or specific [10]. Recent studies have focused on

combining uterine artery Doppler results with maternal factors and biochemical indicators to improve predictive accuracy. Nevertheless, in resource-limited settings, more sophisticated biomarkers may be unavailable, and Doppler-based screening can be a more viable and affordable alternative [11,12].

OBJECTIVE

To evaluate the role of first-trimester uterine artery Doppler in predicting preeclampsia.

METHODOLOGY

This was a prospective observational study conducted at Department of Obs and Gyne DHQ Bhakkar from march 2024 to march 2025. A total of 189 pregnant women were enrolled in the study. Non-probability consecutive sampling was used to recruit participants who met the inclusion criteria. All pregnant women presenting for routine antenatal care during the first trimester (11–14 weeks of gestation) were assessed for eligibility. Gestational age was confirmed using last menstrual period and/or first-trimester ultrasound findings.

Inclusion Criteria

1. Singleton pregnancies
2. Gestational age between 11 and 14 weeks
3. Willingness to participate in the study

Exclusion Criteria

1. Multiple pregnancies
2. Known chronic hypertension
3. Pre-existing renal disease
4. Diabetes mellitus
5. Autoimmune disorders
6. Known fetal congenital anomalies

Data Collection Procedure

After obtaining informed consent, baseline demographic and clinical data were recorded using a structured proforma. These were maternal age, parity, body mass index, and pertinent obstetric history. All participants were taken through a standardized transabdominal procedure of uterine artery Doppler ultrasonography between 11 and 14 weeks of gestation. The uterine arteries were located at the point of crossing the external iliac arteries. Doppler waveforms were recorded and measurements of such indices as pulsatility index (PI), resistance index (RI), and the existence or absence of early diastolic notching were documented. The average uterine artery PI was then obtained by taking the average of the right and left uterine arteries. Abnormal Doppler results were considered to be above the 95 th percentile of the mean uterine artery PI according to

gestational age and/or bilateral early diastolic notching. The group was observed during pregnancy period till delivery through periodic antenatal visits. Preeclampsia and its consequences were monitored. The main result was the emergence of preeclampsia which is considered to be the new-onset blood pressure (high blood pressure 140/90mmHg on two occasions at least four hours apart after 20 weeks gestation) and the presence of proteinuria or dysfunction of end organs. Secondary outcomes were early-onset preeclampsia (before 34 weeks), late-onset preeclampsia (after 34 weeks), and maternal and fetal complications.

DATA ANALYSIS

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. The association between uterine artery Doppler findings and the development of preeclampsia was assessed using the chi-square test and independent t-test where appropriate. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated to evaluate the diagnostic performance of uterine artery Doppler. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

A total of 189 pregnant women were included in the study. The mean age of participants was 27.9 ± 4.8 years, with the majority belonging to the 25–30 years age group (45.5%), followed by those older than 30 years (29.1%) and those younger than 25 years (25.4%). Most participants were multigravida (59.3%), while 40.7% were primigravida. The mean body mass index was 25.8 ± 3.6 kg/m². The mean uterine artery pulsatility index (PI) was 1.72 ± 0.46 . Normal Doppler findings were observed in 74.6% of participants, whereas 25.4% had abnormal Doppler indices. Early diastolic notching was present in 16.4% of cases.

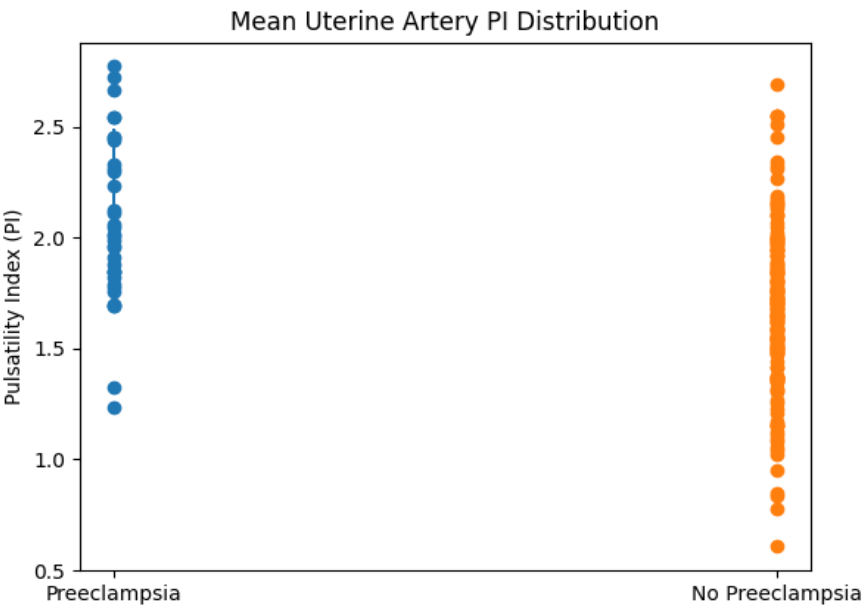
Table 1: Baseline Demographic and Clinical Characteristics (n = 189)

Variable	Category	n (%) / Mean $\pm$ SD
Age (years)	—	27.9 ± 4.8
Age Group	<25 years	48 (25.4%)
	25–30 years	86 (45.5%)
	>30 years	55 (29.1%)
Parity	Primigravida	77 (40.7%)
	Multigravida	112 (59.3%)
BMI (kg/m ²)	—	25.8 ± 3.6
Mean Uterine Artery PI	—	1.72 ± 0.46
Doppler Findings	Normal	141 (74.6%)
	Abnormal	48 (25.4%)
Early Diastolic Notching	Present	31 (16.4%)
	Absent	158 (83.6%)
Preeclampsia	Present	34 (18.0%)
	Absent	155 (82.0%)
Type of Preeclampsia	Early-onset (<34 weeks)	12 (6.3%)
	Late-onset (≥ 34 weeks)	22 (11.6%)

Among women who developed preeclampsia, 61.8% had abnormal Doppler findings compared to only 17.4% among those who remained normotensive ($p < 0.001$). Conversely, normal Doppler findings were more common in women without preeclampsia (82.6%) than in those who developed the condition (38.2%). The mean uterine artery PI was significantly higher in women with preeclampsia (2.11 ± 0.38) compared to those without (1.63 ± 0.42) ($p < 0.001$).

Table 2: Association Between Doppler Findings and Preeclampsia

Variable	Preeclampsia Present (n = 34)	Preeclampsia Absent (n = 155)	p-value
Abnormal Doppler	21 (61.8%)	27 (17.4%)	<0.001
Normal Doppler	13 (38.2%)	128 (82.6%)	<0.001
Mean PI	2.11 ± 0.38	1.63 ± 0.42	<0.001
Bilateral Notching Present	19 (55.9%)	12 (7.7%)	<0.001
Bilateral Notching Absent	15 (44.1%)	143 (92.3%)	<0.001



Preterm delivery occurred in 41.2% of women with preeclampsia compared to 12.3% in those without ($p < 0.001$). The rate of cesarean section was also higher in the preeclampsia group (52.9% vs 34.8%, $p = 0.048$). Adverse fetal outcomes were more frequent among affected pregnancies, with low birth weight observed in 52.9% of cases compared to 13.5% in the normotensive group ($p < 0.001$). Similarly, intrauterine growth restriction was significantly higher in the preeclampsia group (41.2% vs 7.7%, $p < 0.001$).

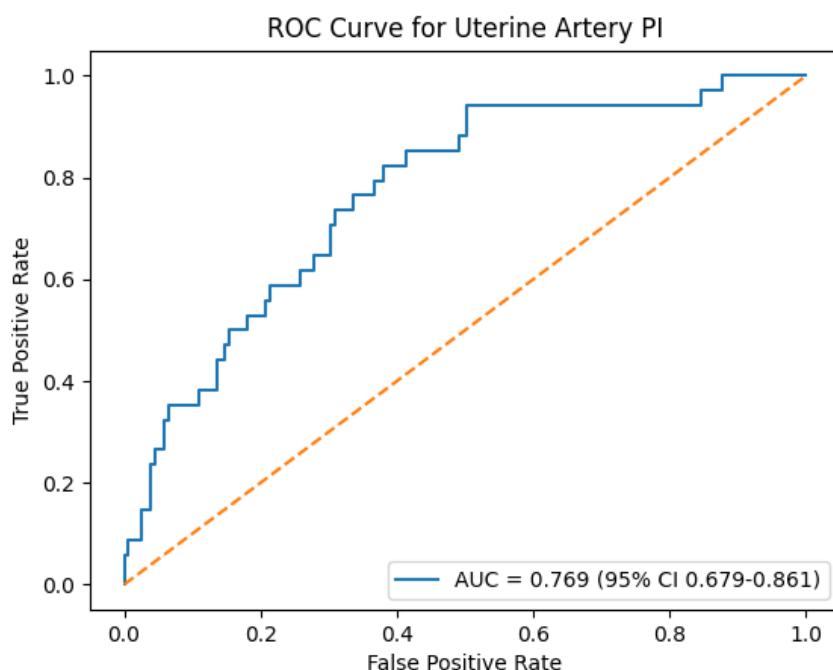
Table 3: Maternal and Fetal Outcomes According to Preeclampsia Status

Variable	Preeclampsia (n = 34)	No Preeclampsia (n = 155)	p-value
Preterm Delivery	14 (41.2%)	19 (12.3%)	<0.001
Cesarean Section	18 (52.9%)	54 (34.8%)	0.048
Low Birth Weight (<2.5 kg)	18 (52.9%)	21 (13.5%)	<0.001
Intrauterine Growth Restriction	14 (41.2%)	12 (7.7%)	<0.001

Uterine artery Doppler demonstrated moderate sensitivity (61.8%) and high specificity (85.8%) for predicting preeclampsia. The positive predictive value was 43.8%, while the negative predictive value was high at 90.8%, indicating that a normal Doppler result is strongly associated with a lower risk of disease.

Table 4: Diagnostic Performance of Uterine Artery Doppler

Parameter	Value (%)
Sensitivity	61.8%
Specificity	85.8%
Positive Predictive Value (PPV)	43.8%
Negative Predictive Value (NPV)	90.8%
Sensitivity (Bilateral Notching)	55.9%
Specificity (Bilateral Notching)	92.3%



DISCUSSION

The current research examined the predictability of first-trimester uterine artery Doppler to identify the onset of preeclampsia and proved that bilateral early diastolic notching and high pulsatility index (PI) were significantly linked to future incidence of the disease. The cumulative preeclampsia rate in this cohort was 18.0, which compares with the rates of the disease in similar hospital-based groups, especially those with low and middle income, where the burden of the disease is frequently found to be high. One of the most important conclusions of the research is a strong correlation between the abnormal uterine artery Doppler parameters and the occurrence of preeclampsia. Females with abnormal Doppler were at high risk of preeclampsia than those with normal indices (43.8% vs 9.2, $p < 0.001$). On the same note,

the mean PI of the uterine artery was significantly higher among the women who developed preeclampsia, indicating that elevated resistance in the early pregnancy is indicative of poor placentation. These results are in line with other studies, which have revealed that high PI of the uterine artery during the first trimester is linked to impaired trophoblastic invasion and higher chances of developing hypertensive disorders during pregnancy. Similar trends have been reported previously, suggesting that uterine artery Doppler can serve as an early indicator of abnormal placental development [13].

Bilateral early diastolic notching was also found to be significantly related to preeclampsia in the current study, with over half of the affected women showing this observation. This finding is consistent with prior studies indicating that persistent notching indicates

greater impedance to the blood supply and is also linked to more severe disease. The specificity observed in this study for notching is also consistent with it being a valuable marker for identifying a high-risk pregnancy, but the relatively low sensitivity of notching suggests that it cannot be used to screen on its own [14]. The distinction between early-onset and late-onset preeclampsia is also an important point of this study. Abnormal Doppler results correlated more with early-onset disease, and most cases with early-onset were characterised by abnormal indices. This is in line with the known fact that early preeclampsia is more directly related to placental insufficiency, and late-onset illness could be even more heterogeneous, with maternal factors involved [15,16]. Similar findings regarding the clinical relevance of uterine artery Doppler in detecting more severe disease phenotypes have been reported in the literature, indicating that it is more predictive of early-onset preeclampsia than late-onset preeclampsia [17].

The diagnostic value of uterine artery Doppler in the given study is also supported by its clinical use. The sensitivity is 61.8%, and the specificity is 85.8%, which suggests that although Doppler screening is not entirely ineffective at identifying people at high risk, it can still fail to detect some cases when applied individually. The negative predictive value is high (90.8), indicating that a normal Doppler study is reassuring and is associated with a reduced risk of preeclampsia [18]. These results are consistent with those reported in earlier studies, which have suggested moderate sensitivity but high specificity for first-trimester uterine artery Doppler. This supports the idea that Doppler assessment should be used as part of a combined screening strategy that considers maternal risk factors, along with biochemical markers where possible. The observed maternal and fetal outcomes in this study also underscore the clinical importance of early prediction [19]. Women with preeclampsia were much more likely to deliver preterm and to have a cesarean section, which is a sign of more obstetric intervention and complications related to it. On the same note, the negative fetal outcomes of low birth weight and intrauterine growth restriction were more common in the preeclampsia group as expected of placental insufficiency [20,21]. These results can be compared to the previous studies that prove that preeclampsia is linked with a significant level of perinatal morbidity and underline the need to identify risk early to achieve better outcomes.

LIMITATIONS

This research has several limitations that should be considered when interpreting the results. The sample of 189 participants and the single-centre design can be a limitation to the extrapolation of the results to more generalised populations and create the possibility of

selection bias. Uterine artery Doppler is operator dependent and even with standardized protocols there is still a possibility of variability in measurements. The researchers used Doppler as an independent screening tool in the study, without biochemical screening measures such as placental growth factor or pregnancy-associated plasma protein-A, which could have enhanced predictive power. Also, the key confounding variables such as socioeconomic status, nutritional status, and lifestyle variables were not completely evaluated. There were no serial Doppler measurements, and assessment of temporal changes in uterine blood flow was not done, and there was no evaluation of long-term maternal and neonatal outcome. Lastly, the results are an association because the study is an observational study and does not prove causality

CONCLUSION

First-trimester uterine artery Doppler is a useful non-invasive tool for early prediction of preeclampsia, with abnormal findings such as elevated pulsatility index and bilateral notching significantly associated with increased risk of disease, particularly early-onset forms. The technique demonstrates good specificity and high negative predictive value, making it valuable for risk stratification in early pregnancy. However, its moderate sensitivity suggests that it is best utilized as part of a combined screening approach rather than a standalone test.

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