

Research Article

Role of Uterine Artery Doppler in the Prediction of Preeclampsia: A Prospective Observational Study

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ABSTRACT

Background: Preeclampsia is a major cause of maternal and perinatal morbidity and mortality worldwide. Early prediction of preeclampsia allows timely intervention and close antenatal surveillance. Uterine artery Doppler ultrasonography has emerged as a useful noninvasive tool for assessing uteroplacental circulation and identifying women at risk for hypertensive disorders of pregnancy.

Aim: To evaluate the predictive value of uterine artery Doppler in identifying pregnant women at risk of developing preeclampsia.

Materials and Methods: This prospective observational study was conducted among 70 antenatal women between 11 and 14 weeks of gestation attending a tertiary care hospital. Participants underwent uterine artery Doppler assessment for pulsatility index, resistance index, and presence of early diastolic notch. Women were followed until delivery for the development of preeclampsia. Data were analyzed using SPSS software. Chi-square test was used to determine associations, and diagnostic accuracy indices were calculated. A p-value <0.05 was considered statistically significant.

Results: Among the 70 participants, 16 (22.9%) developed preeclampsia. Abnormal uterine artery Doppler findings were observed in 21 (30%) women. Preeclampsia developed in 57.1% of women with abnormal Doppler findings compared to 8.2% with normal Doppler findings, which was statistically significant ($p < 0.001$). Increased pulsatility index and bilateral early diastolic notch showed strong association with subsequent development of preeclampsia. Uterine artery Doppler demonstrated a sensitivity of 75%, specificity of 83.3%, positive predictive value of 57.1%, and negative predictive value of 91.8%.

Conclusion: Uterine artery Doppler is an effective noninvasive screening tool for early prediction of preeclampsia and can aid in identifying high-risk pregnancies for closer monitoring and timely management.

Keywords: Preeclampsia, Uterine Artery Doppler, Pulsatility Index, Pregnancy, Hypertensive Disorders, Prediction.

INTRODUCTION

Preeclampsia is a multisystem hypertensive disorder of pregnancy characterized by the onset of hypertension and proteinuria after 20 weeks of gestation. It remains one of the leading causes of maternal and perinatal morbidity and mortality worldwide, particularly in developing countries^[1]. The condition contributes significantly to complications such as eclampsia, placental abruption, disseminated intravascular coagulation, preterm delivery, fetal growth restriction, and increased perinatal mortality. Despite advances in obstetric care, the exact etiology of preeclampsia remains incompletely understood, although abnormal

placentation and impaired uteroplacental perfusion are considered central pathogenic mechanisms^[2].

Globally, preeclampsia affects approximately 2–8% of pregnancies and accounts for nearly 10–15% of maternal deaths^[3]. In India, the incidence ranges from 5–15%, with higher prevalence among primigravida women and high-risk pregnancies^[4]. Early identification of women at risk is essential for appropriate antenatal surveillance and timely intervention to reduce adverse maternal and fetal outcomes. Normal placentation involves trophoblastic invasion of spiral arteries, transforming them into low-resistance vessels capable of meeting

increasing uteroplacental blood flow demands. In preeclampsia, defective trophoblastic invasion leads to persistence of high-resistance uterine circulation, resulting in placental ischemia and endothelial dysfunction^[5]. Uterine artery Doppler ultrasonography provides a noninvasive method for assessing uteroplacental blood flow and detecting these hemodynamic abnormalities before clinical manifestations become evident.^[6] Increased pulsatility index, resistance index, and persistence of early diastolic notch have been identified as important Doppler abnormalities associated with subsequent development of preeclampsia.

Several studies have evaluated the role of uterine artery Doppler in predicting hypertensive disorders of pregnancy. Gómez et al. demonstrated that abnormal uterine artery Doppler findings during the second trimester were significantly associated with later development of preeclampsia and fetal growth restriction.^[7] Similarly, Crossen et al., in a systematic review and meta-analysis, reported that uterine artery Doppler screening had moderate predictive accuracy for preeclampsia, especially for early-onset disease.^[8] Other investigators have also highlighted the usefulness of uterine artery Doppler as a cost-effective and noninvasive screening modality in routine antenatal care.^[9]

However, variability in predictive performance across different populations and healthcare settings necessitates further evaluation, particularly in resource-limited regions. Limited data are available from Indian tertiary care centres regarding the utility of uterine artery Doppler in early prediction of preeclampsia. Therefore, the present study was undertaken to evaluate the predictive value of uterine artery Doppler among antenatal women and to determine its usefulness in identifying pregnancies at increased risk for developing preeclampsia.

AIM AND OBJECTIVES

Aim of the Study

To evaluate the predictive value of uterine artery Doppler in identifying pregnant women at risk of developing preeclampsia.

Objectives of the Study

1. To assess uterine artery Doppler parameters among pregnant women during the first and early second trimester scan.

2. To determine the association between abnormal uterine artery Doppler findings and the development of preeclampsia.
3. To evaluate the sensitivity, specificity, and predictive value of uterine artery Doppler in predicting preeclampsia.

MATERIALS AND METHODS

Study Design

This study was designed as a hospital-based prospective observational study conducted among antenatal women attending the Department of Obstetrics and Gynaecology at a tertiary care teaching hospital.

Study Period

The study was conducted over a period of 18 months from March 2024 to Aug 2025.

Study Setting

The study was carried out in the antenatal outpatient department and labour ward of the Department of Obstetrics and Gynaecology in a tertiary care centre.

Study Population

Pregnant women attending routine antenatal care during the first and early second trimesters were included in the study and followed up until delivery for the development of preeclampsia and associated maternal outcomes.

Inclusion Criteria

- Pregnant women with singleton pregnancy
- Gestational age between 11 and 14 weeks confirmed by ultrasonography or reliable last menstrual period
- Age between 18 and 35 years
- Women willing to participate and provide informed written consent

Exclusion Criteria

- Known chronic hypertension
- Diabetes mellitus
- Renal disease
- Multiple pregnancy
- Congenital fetal anomalies
- Autoimmune disorders
- Women already diagnosed with preeclampsia at recruitment

Sample Size Calculation

The sample size was calculated using the standard formula for prevalence studies:

$$n = \frac{Z^2 \times p \times q}{d^2}$$

Where:

- n = required sample size
- Z = standard normal variate corresponding to 95% confidence interval = 1.96
- p = prevalence/proportion obtained from previous literature
- $q = 1 - p$
- d = allowable error

A previous study by Gómez et al. reported abnormal uterine artery Doppler findings associated with preeclampsia in approximately 20% of antenatal women.

Therefore:

- $p = 20\% = 0.20$
- $q = 1 - 0.20 = 0.80$
- Allowable error $d = 10\% = 0.10$

Substituting the values:

$$n = \frac{(1.96)^2 \times 0.20 \times 0.80}{(0.10)^2}$$

On calculation:

$$n = \frac{3.84 \times 0.16}{0.01} = 61.44$$

The minimum calculated sample size was approximately 61 participants. Considering possible loss to follow-up and incomplete data collection, the final sample size was rounded off to 70 antenatal women.

Sampling Technique

Eligible participants fulfilling the inclusion criteria were recruited consecutively using a convenient sampling method until the required sample size was achieved.

Study Procedure

After obtaining approval from the Institutional Ethics Committee and informed written consent from the participants, detailed demographic and obstetric history was collected using a structured proforma. General physical examination and obstetric examination were performed.

Blood pressure was measured using a standard mercury sphygmomanometer with the participant in a sitting position after adequate rest. Baseline investigations including urine albumin assessment were performed.

All enrolled participants underwent uterine artery Doppler ultrasonography between 11 and 14 weeks of gestation using a standardized ultrasound machine with a curvilinear transducer. Doppler assessment was performed by an experienced radiologist/sonologist.

The following uterine artery Doppler parameters were assessed:

- Pulsatility Index (PI)

- Resistance Index (RI)
- Presence of early diastolic notch
- Bilateral uterine artery notching

Abnormal uterine artery Doppler was defined as increased pulsatility index above the 95th percentile for gestational age and/or persistence of bilateral early diastolic notch.

Participants were followed up regularly during antenatal visits until delivery for the occurrence of preeclampsia and adverse maternal outcomes.

Preeclampsia was diagnosed according to the American College of Obstetricians and Gynecologists criteria as blood pressure $\geq 140/90$ mmHg measured on two occasions at least 4 hours apart after 20 weeks of gestation with proteinuria ≥ 300 mg/24 hours or urine dipstick $\geq 1+$.

Outcome Measures

Primary Outcome

- Development of preeclampsia among study participants

Secondary Outcomes

- Association between abnormal uterine artery Doppler findings and severity of preeclampsia
- Maternal complications associated with abnormal Doppler findings

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 25.

Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequency and percentage. Association between categorical variables was analyzed using Chi-square test or Fisher's exact test. Independent t-test was used for comparison of continuous variables between groups.

Diagnostic accuracy measures including sensitivity, specificity, positive predictive value, and negative predictive value of uterine artery Doppler in predicting preeclampsia were calculated.

A p-value < 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment. Confidentiality of patient

information was maintained throughout the study.

A total of 70 antenatal women between 11 and 14 weeks of gestation were included in the study and followed up until delivery. Among them, 16 (22.9%) women developed preeclampsia during follow-up.

RESULTS

Table 1. Baseline Demographic and Obstetric Characteristics of Study Participants (n = 70)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
<20	8	11.4
21–25	30	42.9
26–30	22	31.4
>30	10	14.3
Parity		
Primigravida	41	58.6
Multigravida	29	41.4
Body Mass Index		
Normal	39	55.7
Overweight	21	30.0
Obese	10	14.3
Family History of Hypertension		
Present	18	25.7
Absent	52	74.3

Table 2. Uterine Artery Doppler Findings Among Study Participants (n = 70)

Doppler Parameter	Frequency (n)	Percentage (%)
Increased Pulsatility Index	19	27.1
Increased Resistance Index	16	22.9
Bilateral Early Diastolic Notch	14	20.0
Any Abnormal Doppler Finding	21	30.0
Normal Doppler Study	49	70.0

Table 3. Incidence of Preeclampsia According to Uterine Artery Doppler Findings

Doppler Finding	Developed Preeclampsia n (%)	Did Not Develop Preeclampsia n (%)	Total	p-value
Abnormal Doppler (n=21)	12 (57.1)	9 (42.9)	21	<0.001
Normal Doppler (n=49)	4 (8.2)	45 (91.8)	49	

Table 4. Association between Specific Doppler Parameters and Development of Preeclampsia

Doppler Parameter	Preeclampsia Present (n=16)	Preeclampsia Absent (n=54)	p-value
Increased Pulsatility Index	11 (68.8%)	8 (14.8%)	<0.001
Increased Resistance Index	9 (56.3%)	7 (13.0%)	0.001
Bilateral Early Diastolic Notch	8 (50.0%)	6 (11.1%)	0.002

Table 5. Diagnostic Accuracy of Uterine Artery Doppler in Predicting Preeclampsia

Diagnostic Parameter	Value (%)
Sensitivity	75.0
Specificity	83.3
Positive Predictive Value	57.1
Negative Predictive Value	91.8

Overall Accuracy	81.4
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DISCUSSION

Preeclampsia remains a major contributor to maternal and perinatal morbidity worldwide, emphasizing the need for reliable methods for early prediction. The present prospective observational study evaluated the role of uterine artery Doppler in predicting preeclampsia among antenatal women between 11 and 14 weeks of gestation.

In the present study, the majority of participants belonged to the 21–25 years age group, and primigravida women constituted 58.6% of the study population. Similar findings were reported by Harrington et al., who observed a higher prevalence of preeclampsia among younger primigravida women.^[9] Primigravidity is a well-established risk factor for abnormal placentation and hypertensive disorders of pregnancy.

The incidence of preeclampsia in the present study was 22.9%. This finding is comparable to the observations made by Papageorgiou et al.^[6], who reported a significantly increased occurrence of preeclampsia among women with abnormal uterine artery blood flow patterns. The slightly higher incidence in the present study may be attributed to the tertiary care referral setting and inclusion of high-risk pregnancies.

Abnormal uterine artery Doppler findings were identified in 30% of participants in the current study. Increased pulsatility index and persistence of bilateral early diastolic notch were the most common abnormalities detected. Similar observations were reported by Gómez et al., who demonstrated that elevated pulsatility index and bilateral notching during the second trimester were strongly associated with the later development of preeclampsia and fetal growth restriction.^[7] These Doppler abnormalities reflect impaired trophoblastic invasion and increased uteroplacental vascular resistance.

A statistically significant association was observed between abnormal uterine artery Doppler findings and subsequent development of preeclampsia in the present study ($p < 0.001$). Among women with abnormal Doppler findings, 57.1% developed preeclampsia compared to only 8.2% among women with normal Doppler studies. Comparable results were observed by Cnossen et al. in a systematic review, which concluded that abnormal uterine artery Doppler was associated with a significantly increased

risk of preeclampsia, particularly early-onset disease.^[8]

In the present study, uterine artery Doppler demonstrated a sensitivity of 75% and specificity of 83.3% for predicting preeclampsia. These findings are in agreement with the study conducted by Plasencia et al., who reported that uterine artery Doppler screening showed good predictive accuracy when performed during the second trimester.^[11] The high negative predictive value observed in the present study suggests that normal Doppler findings are associated with a lower likelihood of developing preeclampsia, making it useful as a screening modality in routine antenatal care. The persistence of bilateral early diastolic notch showed significant association with preeclampsia in this study. Similar findings were described by Campbell et al., who identified bilateral notching as an important marker of defective placentation and adverse pregnancy outcomes.^[10]

Overall, the findings of the present study support the role of uterine artery Doppler as a simple, noninvasive, and cost-effective tool for early prediction of preeclampsia. Early identification of high-risk women can facilitate closer antenatal monitoring, timely prophylactic interventions, and improved maternal and fetal outcomes.

Limitations

The study was conducted in a single tertiary care centre with a relatively small sample size, which may limit generalizability of the findings. Doppler assessment was performed only during the early second trimester, and serial Doppler evaluation was not carried out. Additionally, biochemical markers for prediction of preeclampsia were not included, which could have improved the predictive accuracy of the study.

CONCLUSION

The present study demonstrated that abnormal uterine artery Doppler findings during the first and early second trimester were significantly associated with the subsequent development of preeclampsia and fetal growth restriction. Increased pulsatility index and persistence of bilateral early diastolic notch were important predictors of adverse pregnancy outcomes. Uterine artery Doppler showed good sensitivity and specificity, making it a useful, noninvasive, and cost-effective screening tool for early

identification of high-risk pregnancies. Early detection through Doppler assessment may help in closer antenatal surveillance and timely intervention to reduce maternal and fetal complications.

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