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Original Research Article

Second Trimester Uterine Artery Doppler as a Radiological Screening Tool for Preeclampsia: Prospective Observational Evaluation with Emphasis on Negative Predictive Value

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Abstract

Background: Preeclampsia is a pregnancy-related hypertensive condition associated with significant maternal and fetal morbidity and mortality. It arises due to impaired placental vascular remodeling leading to persistently elevated uteroplacental resistance, which can be assessed non-invasively using uterine artery Doppler ultrasound. The present study examines the role of second trimester uterine artery Doppler in identifying pregnancies unlikely to develop preeclampsia, with particular emphasis on the negative predictive value (NPV) of resistance index (RI), pulsatility index (PI) and protodiastolic notch.

Methods: A prospective observational study was conducted in 100 pregnant women undergoing routine anomaly scanning between 18 and 21 weeks of gestation. Bilateral uterine artery Doppler interrogation was performed. Abnormal Doppler was defined as RI and PI > 95th percentile for gestational age. Pregnancy outcomes were recorded, and diagnostic accuracy parameters were calculated.

Results: Preeclampsia occurred in 15% of the cohort. Right uterine artery RI showed strong statistical association with disease development and demonstrated high sensitivity (86.7%) with excellent NPV (96.8%). Across all Doppler parameters, NPV exceeded 90%, indicating strong exclusionary performance.

Conclusion: Normal second-trimester uterine artery RI reliably excludes preeclampsia and supports the role of Doppler ultrasound as a screening adjunct.

Keywords: Uterine Artery Doppler; Preeclampsia Screening; Resistance Index; Pulsatility Index; Negative Predictive Value; Positive Predictive Value.

Introduction

Preeclampsia continues to pose a major challenge in obstetric care due to its variable presentation and unpredictable progression. The risk of sudden and severe complications affecting both the mother and fetus underscores the need for reliable screening approaches that can accurately distinguish pregnancies at increased risk from those that are unlikely to develop the disorder.

The condition develops due to defective placental implantation, characterized by insufficient invasion of the maternal spiral arteries by cytotrophoblasts.

Consequently, normal transformation of the uteroplacental circulation into a low-resistance vascular system does not occur, resulting in prolonged placental under perfusion and widespread endothelial dysfunction. Importantly, these vascular changes arise well before the onset of overt clinical symptoms.[1] Uterine artery Doppler ultrasonography offers a safe and non-invasive method to evaluate these underlying circulatory alterations.

Assessment during the second trimester is particularly appropriate, as placental vascular remodeling is expected to be completed by this stage, allowing identification of abnormal uteroplacental blood flow patterns.[2]

In the context of population-based screening, reliably excluding disease can be more clinically useful than merely predicting its occurrence. A strong negative predictive value allows effective identification of pregnancies at low risk, thereby minimizing unwarranted investigations and interventions. Accordingly, the present study emphasizes second-trimester uterine artery Doppler

parameters as a screening approach for preeclampsia.

Materials and Methods

This prospective observational study was performed in a tertiary care teaching hospital after approval from the institutional ethics committee. Pregnant women presenting for routine mid-trimester ultrasound examination between 18 and 21 weeks of gestation were invited to participate following informed consent.

Only singleton pregnancies were included. Women with pre-existing hypertension, renal or systemic disease, diabetes mellitus, autoimmune conditions, multiple gestation, major fetal anomalies, or intrauterine fetal demise were excluded to minimize confounding factors.

Ultrasound examinations were conducted using high-resolution equipment with color and pulsed Doppler capability. Both uterine arteries were identified at their anatomical crossing with the external iliac arteries. Doppler sampling was obtained with appropriate angle correction, and multiple consistent waveforms were analyzed. Resistance index and pulsatility index were measured bilaterally. RI and PI exceeding 95th percentile for gestational age were considered abnormal. The presence of early diastolic notching was noted where present. Participants were followed until delivery, and pregnancy outcomes were documented.[3-5] Statistical analysis involved assessment of association using chi-square or Fisher's exact tests. Diagnostic accuracy parameters, including sensitivity, specificity, positive predictive value, and negative predictive value, were calculated.

Results

Among the 100 women included in the study, 15 developed preeclampsia. Most Doppler examinations were performed between 19 and 20 weeks of gestation.

Resistive index (RI) of right uterine artery results showed 62 patients (62%) had normal values and 38 patients (38%) had elevated values. Pulsatility index (PI) analysis revealed 86 patients (86%) with normal values and 14 patients (14%) with elevated values. Diastolic notch was present in 11 patients (11%) and absent in 89 patients (89%).

Resistive index (RI) of left uterine artery results showed 59 patients (59%) had normal values and 41 patients (41%) had elevated values. Pulsatility index analysis revealed 80 patients (80%) with normal values and 20 patients (20%) with elevated values. Diastolic notch was present in 10 patients (10%) and absent in 90 patients (90%).

Table 1: Association between RUA RI and Pre-eclampsia

RUA RI	Pre-eclampsia		Total
	Yes	No	
Elevated (+)	13 (34.2%) A	25 (65.8%) b	38 (100%)
Normal (-)	2 (3.2%) c	60 (96.8%) d	62 (100%)
Total	15 (15%)	85 (85%)	100 (100%)
Fisher's exact test, n=100, $p < 0.001$			

The diagnostic accuracy analysis revealed that elevated RUA RI demonstrated good sensitivity for detecting pre-eclampsia at 86.7% (13/15). The specificity was 70.6% (60/85), indicating that normal RUA RI correctly excluded pre-eclampsia in approximately two-thirds of patients who remained normotensive. The positive predictive value (PPV) was 34.2% (13/38). Notably, the negative predictive value (NPV) was high at 96.8% (60/62), indicating that patients with normal RUA RI have a very low probability of developing pre-eclampsia.

Table 2: Association between RUA PI and Pre-eclampsia

RUA PI	Pre-eclampsia		Total
	Yes	No	
Elevated (+)	7 (50%) a	7 (50%) b	14 (100%)
Normal (-)	8 (9.3%) c	78 (90.7%) d	86 (100%)
Total	15 (15%)	85 (85%)	100 (100%)
χ^2 value = 15.6, df = 1, $p < 0.001$			

RUA PI showed moderate sensitivity (46.7%) and high specificity (91.8%) for predicting pre-eclampsia, with a positive predictive value of 50.0% and negative predictive value of 90.7%. The association between elevated RUA PI and pre-eclampsia was statistically significant ($p < 0.001$).

Table 3: Association between LUA RI and Pre-eclampsia

LUA RI	Pre-eclampsia		Total
	Yes	No	
Elevated (+)	10 (24.4%) a	31 (75.6%) b	41 (100%)
Normal (-)	5 (8.5%) c	54 (91.5%) d	59 (100%)
Total	15 (15%)	85 (85%)	100 (100%)
χ^2 value = 4.81, df = 1, p = 0.028			

LUA RI showed moderate sensitivity (66.7%) and moderate specificity (63.5%) for predicting pre-eclampsia. The positive predictive value was low (24.4%), while the negative predictive value was high (91.5%). Elevated LUA RI was significantly associated with pre-eclampsia ($p = 0.028$).

Table 4: Association between LUA PI and Pre-eclampsia

LUA PI	Pre-eclampsia		Total
	Yes	No	
Elevated (+)	11 (55%) a	9 (45%) b	20 (100%)
Normal (-)	4 (5%) c	76 (95%) d	80 (100%)
Total	15 (15%)	85 (85%)	100 (100%)
χ^2 value = 31.4, df = 1, p < 0.001			

LUA PI demonstrated good sensitivity (73.3%) and high specificity (89.4%) for predicting pre-eclampsia. The positive predictive value was 55.0% and the negative predictive value was excellent (95.0%). Elevated LUA PI showed a strong and highly significant association with pre-eclampsia ($p < 0.001$).

Table 5: Association between Mean PI and Pre-eclampsia

Mean PI	Pre-eclampsia		Total
	Yes	No	
Elevated (+)	7 (43.8%) a	9 (56.3%) b	16 (100%)
Normal (-)	8 (9.5%) c	76 (90.5%) d	84 (100%)
Total	15 (15%)	85 (85%)	100 (100%)
χ^2 value = 12.3, df = 1, p < 0.001			

Among 100 study participants, elevated mean pulsatility index (Mean PI) was observed in 16%, while 15% developed pre-eclampsia.

Pre-eclampsia occurred significantly more often in patients with elevated Mean PI compared to those with normal values (43.8% vs 9.5%; $\chi^2 = 12.3$, $p < 0.001$). Elevated Mean PI showed moderate sensitivity (46.7%) but high specificity (89.4%) for predicting pre-eclampsia, with a PPV of 43.8% and a high NPV of 90.5%, indicating that normal Mean PI is a strong indicator of low risk for pre-eclampsia.

Table 6: Association between Diastolic notch and Pre-eclampsia

Diastolic notch	Pre-eclampsia		Total
	Yes	No	
Present (+)	7 (53.8%) a	6 (46.2%) b	13 (100%)
Absent (-)	8 (9.2%) c	79 (90.8%) d	87 (100%)
Total	15 (15%)	85 (85%)	100 (100%)
χ^2 value = 17.7, df = 1, p < 0.001			

Diastolic notch of the uterine artery was present in 13% of the study population, with an overall pre-eclampsia incidence of 15%. Pre-eclampsia occurred significantly more frequently in patients with a diastolic notch compared to those without (53.8% vs 9.2%; $\chi^2 = 17.7$, $p < 0.001$). The presence of a diastolic notch showed moderate sensitivity (46.7%) but excellent specificity (92.9%) for predicting pre-eclampsia, with a PPV of 53.8% and a high NPV of 90.8%, indicating that absence of a diastolic notch reliably predicts a low risk of pre-eclampsia.

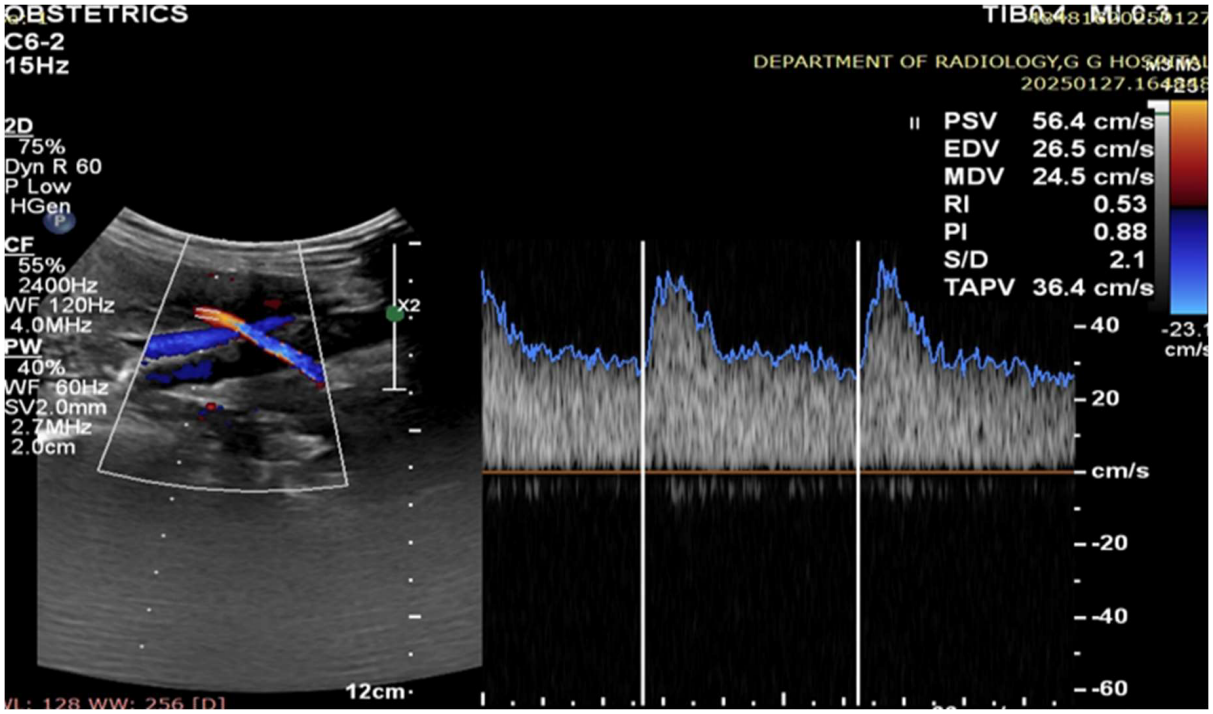

Figure 1: Normal uterine artery Doppler with normal RI and PI and no proto-diastolic notch

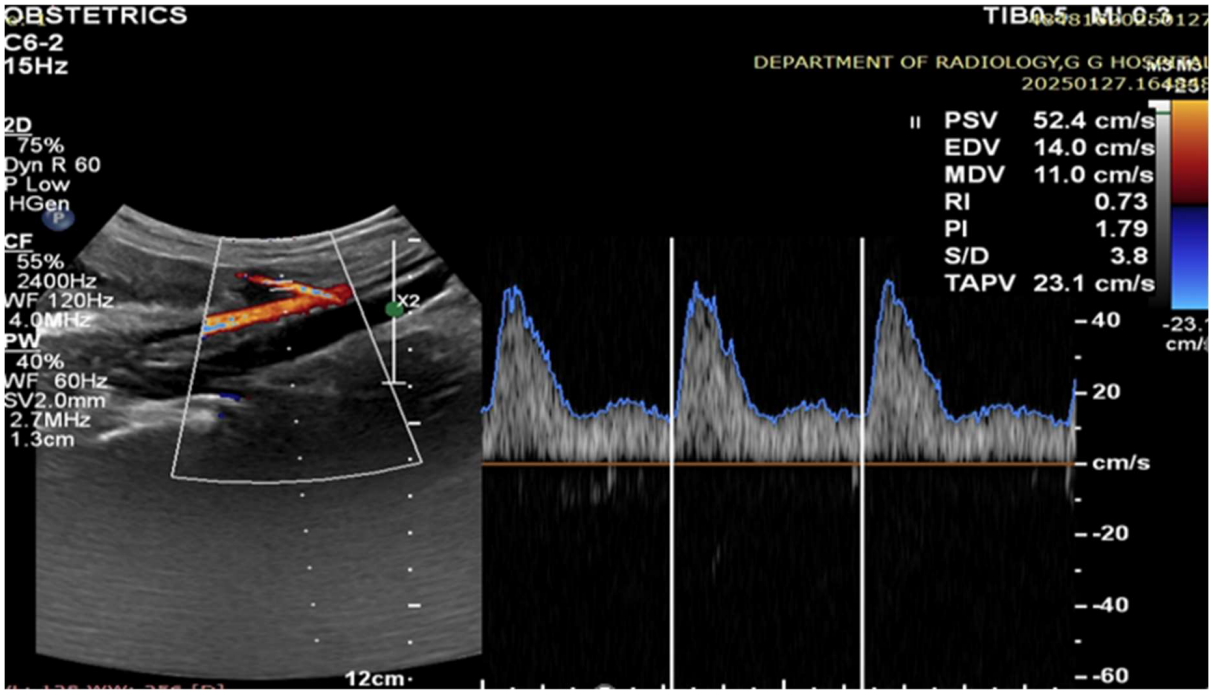

Figure 2: Abnormal uterine artery Doppler with elevated RI and PI and proto-diastolic notch

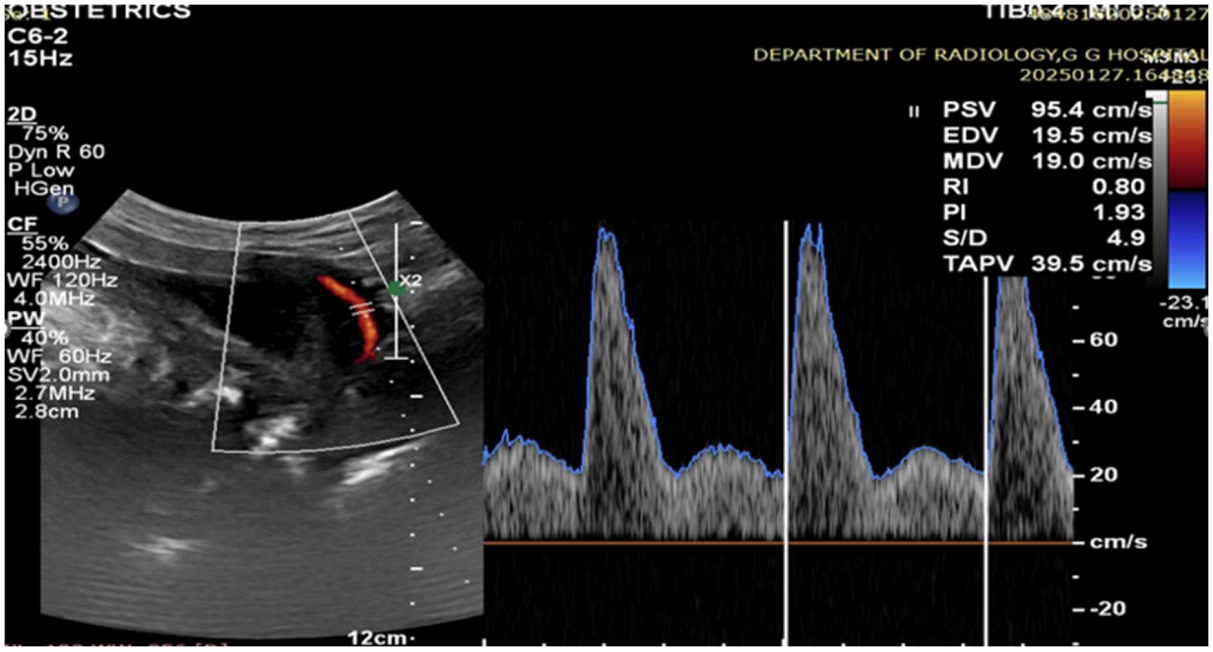

Figure 3: Abnormal uterine artery Doppler with elevated RI and PI and proto-diastolic notch

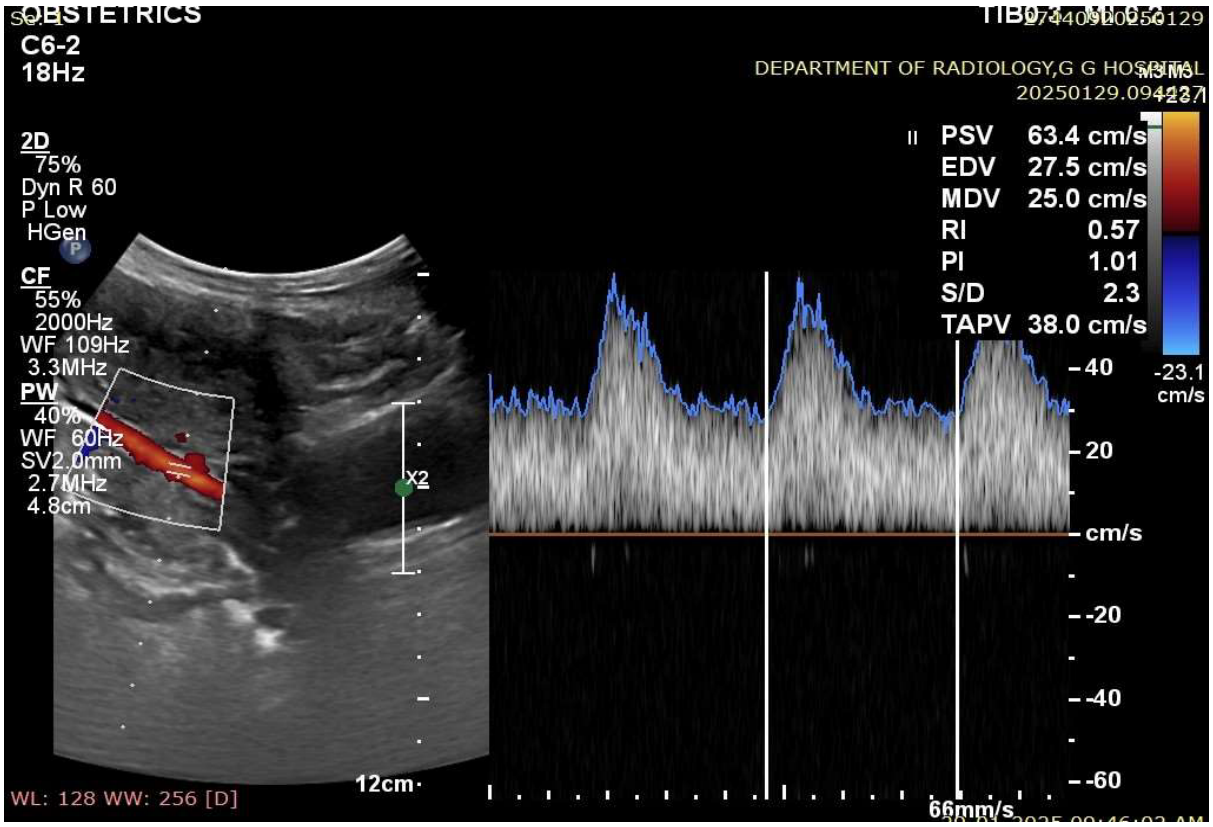

Figure 4: Normal uterine artery Doppler with normal RI and PI and no proto-diastolic notch

Discussion

The results of this study support the use of second-trimester uterine artery Doppler primarily as a screening modality rather than a conclusive diagnostic test for preeclampsia. Among the evaluated indices, the resistance index, especially measured in the right uterine artery proved to be the most dependable parameter for ruling out the condition. Pulsatility index values obtained from the right uterine artery showed a meaningful association with the development of preeclampsia, with high specificity and strong negative predictive value despite relatively lower sensitivity.

Doppler indices from the left uterine artery demonstrated comparable patterns, although their overall diagnostic accuracy was inferior. Mean PI

measurements consistently supported effective exclusion of disease, and across all assessed Doppler parameters, the negative predictive value exceeded 90%.[6,7]

The uniformly strong negative predictive values demonstrated by the Doppler parameters emphasize their practical value in recognizing pregnancies unlikely to develop preeclampsia. This enables more efficient antenatal management by directing surveillance towards women at greater risk, while providing reassurance to those with normal uterine artery Doppler results.[3-5, 7,10,11].

The relatively low positive predictive values observed can be attributed to the multifactorial nature of preeclampsia, particularly in late-onset cases where abnormalities in placental vascular development may be less prominent [6,8,9]. Comparable findings have been documented in large cohort studies and meta-analyses assessing the performance of uterine artery Doppler as a screening tool [4–7,11]. From a radiology perspective, the resistance index has multiple practical benefits, such as ease of measurement, good reproducibility, and negligible extension of examination time. These characteristics favor its inclusion in standard mid-trimester ultrasound evaluations, especially in settings with limited resources [10,12].

The findings endorse uterine artery Doppler as a complementary screening tool, highlighting its strength in ruling out disease rather than predicting its occurrence. This strategy aligns with recommendations from international guidelines as well as Indian population-based research, both of which support the role of uterine artery Doppler in risk assessment and screening for preeclampsia [12–15]. Evidence from systematic reviews and meta-analyses has helped define uterine artery Doppler primarily as a screening method rather than a definitive diagnostic test. In a comprehensive meta-analysis, Cnossen et al. reported that although uterine artery Doppler demonstrates limited sensitivity for predicting preeclampsia, normal Doppler indices are effective in excluding the disease [7].

Papageorghiou et al. were among the first to perform a large multicenter evaluation of mid-trimester uterine artery Doppler and showed that abnormal Doppler parameters around 23 weeks were significantly linked to later development of preeclampsia and fetal growth restriction [2]. This supports the timing used in our study, where Doppler examinations were performed between 18 and 21 weeks, after normal placental vascular remodeling is expected to be complete. Second-trimester uterine artery Doppler assessment coincides with the routine anomaly scan performed at 18–20 weeks of gestation; therefore, this existing clinical visit can be opportunistically utilized to screen for preeclampsia with no additional cost, an approach that is particularly practical and beneficial in low-resource settings.

Conclusion

Second-trimester uterine artery Doppler ultrasound provides valuable information regarding placental vascular resistance. Resistance index, particularly of the right uterine artery, demonstrates excellent negative predictive value and reliably identifies pregnancies unlikely to develop preeclampsia. Including this parameter in routine antenatal ultrasound examinations may therefore contribute to more effective risk assessment and antenatal management.

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