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A clinical study of uterine artery Doppler study indices in early second trimester as predictor of pre-eclampsia

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Abstract
Background: Pre-eclampsia remains a major cause of maternal-perinatal morbidity. Early second-trimester uterine artery Doppler can identify impaired placentation and may help predict pre-eclampsia in routine antenatal care settings. This study assessed uterine artery Doppler indices at 20-24 weeks as predictors of pre-eclampsia at a government tertiary-care hospital in Barasat, West Bengal.
Methods: A prospective observational study was conducted over one year among 100 singleton pregnancies undergoing uterine artery Doppler at 20-24 weeks' gestation. Left and right uterine artery pulsatility index (PI) were measured and mean PI calculated; notching was recorded. Abnormal Doppler was defined as mean uterine artery PI ≥1.30 and/or bilateral early diastolic notching. Participants were followed until delivery for development of pre-eclampsia. Diagnostic accuracy indices were calculated, and ROC analysis was performed for mean PI.
Results: Pre-eclampsia occurred in 12% (12/100), including 4 early-onset (<34 weeks) and 8 late-onset (≥34 weeks) cases; 5/12 (41.7%) had severe features. Mean uterine artery PI was higher among women who developed pre-eclampsia (1.49±0.25) than those who did not (0.99±0.21). Abnormal Doppler was present in 20% overall and was associated with a higher pre-eclampsia incidence (40.0% [8/20] vs 5.0% [4/80]). Abnormal Doppler predicted pre-eclampsia with 66.7% sensitivity, 86.4% specificity, PPV 40.0%, and NPV 95.0% (LR+ 4.89, LR− 0.39). Mean PI showed strong discrimination for pre-eclampsia (AUC 0.94).
Conclusion: Uterine artery Doppler at 20-24 weeks provided clinically useful prediction of pre-eclampsia, with strong rule-out value and clear risk stratification. Incorporation into routine mid-trimester ultrasound may support targeted surveillance in government antenatal services.

Keywords: Pre-eclampsia, uterine artery Doppler, pulsatility index, notching, screening, prediction, India

Introduction

Pre-eclampsia (PE) remains a major contributor to maternal and perinatal morbidity and mortality, particularly in low- and middle-income settings where late presentation and limited resources can amplify adverse outcomes. Clinically, PE is characterised by new-onset hypertension after 20 weeks' gestation, often accompanied by proteinuria or evidence of maternal organ dysfunction and/or uteroplacental compromise [1]. Because clinical disease typically manifests in the late second or third trimester, attention has increasingly shifted toward identifying women at risk earlier in pregnancy so that surveillance and timely interventions can be optimised [2].

A widely accepted mechanistic pathway underlying PE involves defective trophoblastic invasion and impaired spiral artery remodelling, resulting in increased uteroplacental resistance. Uterine artery Doppler velocimetry offers a non-invasive method to interrogate this placentation-related physiology, typically through indices such as pulsatility index (PI), resistance index (RI), systolic/diastolic ratio (S/D), and the presence of an early diastolic notch [2, 3]. At the time of the mid-trimester anomaly scan (approximately 20-24 weeks), uterine artery PI percentiles decline with advancing gestational age, and interpretation often uses gestation-adjusted thresholds (e.g., mean uterine artery PI >95th centile) and/or persistent bilateral notching to define abnormal flow [2].

Evidence supports uterine artery Doppler as a useful screening component, though its standalone performance is modest. Pedroso *et al.* (2018) [3], reviewing multiple studies, noted that as a single predictor, uterine artery Doppler detects fewer than half of PE cases in many settings, but prediction improves when combined with other markers in multivariable risk models [3]. Earlier large screening work by Papageorghiou *et al.* (2001) [4] also demonstrated that second-trimester

uterine artery Doppler at around 23 weeks can identify a substantial proportion of women who subsequently develop severe placental disease, supporting its role as a clinically actionable stratification tool in routine antenatal care [4]. Similarly, large contemporary datasets assessing uterine artery PI around 20-24 weeks have shown meaningful associations between raised PI and PE severity, reinforcing the rationale for using Doppler indices for early identification of higher-risk pregnancies [5].

Despite this literature, predictive performance and optimal cut-offs can vary by population risk profile, gestational timing, technique (transabdominal vs transvaginal), and care pathways factors that are particularly relevant in diverse Indian settings. Therefore, generating locally applicable evidence from government tertiary-care hospitals is valuable for estimating predictive yield and informing feasible surveillance strategies. This study aimed to assess early second-trimester uterine artery Doppler indices as predictors of subsequent PE among antenatal women attending Barasat Government Medical College & Hospital.

Objectives

1. To determine the association of early second-trimester uterine artery Doppler indices (PI/RI/S-D and notching) with subsequent development of pre-eclampsia.
2. To evaluate the predictive performance of abnormal uterine artery Doppler (sensitivity, specificity, PPV, NPV, likelihood ratios) for PE.
3. To identify the best-performing Doppler marker (mean PI vs notching vs combined criteria) for clinical risk stratification.

Materials and Methods

Study design, setting, and duration

A prospective observational (clinical) study was conducted in the Department of Obstetrics and Gynaecology in collaboration with the Radiology/Ultrasound unit at Barasat Government Medical College & Hospital, Barasat, North 24 Parganas, West Bengal, over a one-year period.

Study population and recruitment

Pregnant women attending routine antenatal care were recruited by consecutive sampling until the sample size of 100 was achieved. Enrolment and Doppler evaluation were performed during the early second trimester (20-24 weeks' gestation), corresponding to the routine mid-trimester ultrasound window.

Inclusion criteria

- Singleton pregnancy
- Gestational age 20-24 weeks at the time of uterine artery Doppler
- Willing to provide written informed consent and comply with follow-up

Exclusion criteria

- Known chronic hypertension or pre-gestational diabetes (documented before pregnancy)
- Known renal disease, autoimmune disease, or overt cardiovascular disease
- Multiple gestation
- Major foetal anomaly detected at enrolment scan (as these may independently influence outcomes and surveillance)

Clinical assessment and baseline variables

At enrolment, a structured case record form captured maternal socio-demographic and clinical details, including age, parity, BMI (calculated from measured height and weight), history of pre-eclampsia in a prior pregnancy (where applicable), and relevant medical/obstetric history. Blood pressure was measured using a standardised technique after adequate rest, and baseline urine dipstick findings (if available in routine ANC workflow) were recorded. Participants continued routine ANC follow-up as per institutional protocol.

Uterine artery Doppler protocol

Uterine artery Doppler velocimetry was performed using a transabdominal approach by trained personnel.

- The uterine artery was identified at the apparent crossover with the external iliac artery on each side using colour Doppler.
- A pulsed-wave Doppler sample gate was placed on the vessel, ensuring an insonation angle as close to 0° as feasible (with angle correction when required).
- For each uterine artery (left and right), at least three similar consecutive waveforms with clear systolic and diastolic components were obtained, avoiding foetal movement artefacts.

The following indices were recorded for each side

- Pulsatility index (PI)
- Resistance index (RI)
- Systolic/diastolic ratio (S/D)

Early diastolic notch was assessed visually and recorded as absent, unilateral, or bilateral.

For analysis, the mean uterine artery PI was calculated as the average of left and right uterine artery PI values. Similarly, mean RI and mean S/D were derived where required.

Definition of abnormal uterine artery Doppler

An "abnormal uterine artery Doppler" at 20-24 weeks' gestation was defined using an operational, clinically interpretable criterion: mean uterine artery PI ≥1.30 (mean of left and right PI values) and/or persistent bilateral early diastolic notching. For exploratory subgroup description, abnormalities were categorized as: (i) isolated raised PI (PI ≥1.30 without bilateral notching), (ii) isolated bilateral notching (bilateral notching with PI <1.30), and (iii) combined abnormality (PI ≥1.30 with bilateral notching).

Outcome definition: pre-eclampsia

Participants were followed until delivery for the development of pre-eclampsia (PE). PE was defined as new-onset hypertension after 20 weeks' gestation (systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg on at least two readings) with proteinuria and/or features of maternal organ dysfunction, documented in clinical records. Where sufficient documentation existed, PE was further classified clinically as non-severe and severe according to standard obstetric criteria (e.g., severe-range BP, neurological symptoms, laboratory derangements, foetal growth restriction, or other complications).

Follow-up and data capture: Participants were reviewed as per routine ANC schedules. Blood pressure and urine testing were performed during ANC visits, and any admission, diagnosis of PE, and delivery outcomes were recorded from inpatient files and ANC cards. The primary endpoint was the occurrence of PE at any time after enrolment.

Statistical analysis: Data were summarised using mean± SD (or median with IQR) for continuous variables and frequency (%) for categorical variables.

Analyses included

1. Incidence of PE in the cohort with 95% confidence interval.
2. Comparison of PE incidence between normal vs abnormal Doppler, reported as relative risk/odds ratio with 95% CI.
3. Diagnostic performance of abnormal Doppler for predicting PE: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and likelihood ratios (LR+ and LR−).
4. Receiver operating characteristic (ROC) analysis for mean PI (optional) with area under the curve (AUC) to identify clinically useful thresholds.
5. A multivariable logistic regression model (if feasible with event counts) to assess whether Doppler indices independently predicted PE after adjusting for key clinical covariates (age, BMI, parity, and past history of PE).

A p-value <0.05 was considered statistically significant

Ethical considerations: Institutional Ethics Committee approval was obtained prior to commencement. Written informed consent was taken from all participants. Confidentiality was maintained using anonymized identifiers. Participants identified as clinically high-risk during follow-up were managed according to institutional protocols.

Results

1. Participant inclusion

Over the one-year study period, 100 eligible antenatal women with singleton pregnancies underwent uterine artery Doppler evaluation at 20-24 weeks' gestation at Barasat Government Medical College & Hospital and were followed until delivery for development of pre-eclampsia. All participants had complete Doppler assessment and outcome ascertainment and were included in the final analysis (N=100)

2. Baseline clinical profile and Doppler distribution

The mean maternal age of the cohort was 26.70±3.72 years, and 45% were primigravida. Mean BMI was 24.48±3.17 kg/m², with 40% having BMI ≥25 kg/m². The mean booking mean arterial pressure (MAP) was 88.93±6.20 mmHg.

Overall, the mean uterine artery Doppler indices at 20-24 weeks were: mean UtA PI 1.05±0.27, mean UtA RI 0.48±0.06, and mean UtA S/D 2.27±0.48. Early diastolic notching was absent in 70%, unilateral in 15%, and bilateral in 15%. Using the predefined clinical definition, 20% of women had an abnormal uterine artery Doppler.

Women who later developed pre-eclampsia had a higher booking MAP (95.00±5.08 vs 88.10±5.89 mmHg; $p<0.001$) and significantly higher uterine artery impedance: mean UtA PI (1.49±0.25 vs 0.99±0.21; $p<0.001$), mean UtA RI (0.55±0.05 vs 0.47±0.05; $p<0.001$), and S/D (2.77±0.61 vs 2.20±0.42; p=0.008). Bilateral notching was more frequent among women who developed pre-eclampsia (41.7% vs 11.4%; p=0.018), and abnormal Doppler was present in 66.7% of pre-eclampsia cases versus 13.6% of non-cases ($p<0.001$). BMI ≥25 kg/m² showed a higher proportion among pre-eclampsia cases (66.7% vs 36.4%) but did not reach conventional statistical significance (p=0.061).

Table 1: Baseline clinical and uterine artery Doppler characteristics by pre-eclampsia status (N=100)

Characteristic	Overall (N=100)	No PE (n=88)	PE (n=12)	p value
Maternal age (years), mean ±SD	26.70±3.72	26.61±3.81	27.33±2.99	0.462
Age ≥30 years, n (%)	21 (21.0)	20 (22.7)	1 (8.3)	0.451
BMI (kg/m²), mean ±SD	24.48±3.17	24.18±2.92	26.70±4.17	0.065
BMI ≥25 kg/m², n (%)	40 (40.0)	32 (36.4)	8 (66.7)	0.061
Primigravida, n (%)	45 (45.0)	38 (43.2)	7 (58.3)	0.366
Previous pre-eclampsia, n (%)	6 (6.0)	4 (4.5)	2 (16.7)	0.151
Booking mean arterial pressure (mmHg), mean ±SD	88.93±6.20	88.10±5.89	95.00±5.08	<0.001
Mean uterine artery PI, mean ±SD	1.05±0.27	0.99±0.21	1.49±0.25	<0.001
Mean uterine artery RI, mean ±SD	0.48±0.06	0.47±0.05	0.55±0.05	<0.001
Mean uterine artery S/D ratio, mean ±SD	2.27±0.48	2.20±0.42	2.77±0.61	0.008
Early diastolic notch (overall), p for trend				0.018
None, n (%)	70 (70.0)	65 (73.9)	5 (41.7)	
Unilateral, n (%)	15 (15.0)	13 (14.8)	2 (16.7)	
Bilateral, n (%)	15 (15.0)	10 (11.4)	5 (41.7)	
Abnormal uterine artery Doppler*, n (%)	20 (20.0)	12 (13.6)	8 (66.7)	<0.001

*Abnormal Doppler is defined as mean uterine artery PI ≥1.30 and/or a bilateral early diastolic notch.

3. Incidence and clinical spectrum of pre-eclampsia

During follow-up, 12 of 100 women (12.0%) developed pre-eclampsia (95% CI: 7.0%-19.8%). Of these, 4 (33.3%) were early-onset (<34 weeks) and 8 (66.7%) were late-onset (≥34 weeks). Severe features were documented in 5/12 (41.7%) cases. Mean gestational age at delivery was lower among women with pre-eclampsia (35.3 weeks) compared to those without pre-eclampsia (38.7 weeks).

The incidence of pre-eclampsia differed markedly by Doppler status: 40.0% (8/20) among women with abnormal uterine artery Doppler versus 5.0% (4/80) among those with normal Doppler (Figure 1).

4. Predictive performance of abnormal uterine artery Doppler for pre-eclampsia

Abnormal uterine artery Doppler at 20-24 weeks (mean UtA PI ≥1.30 and/or bilateral notching) correctly identified 8 of 12 women who subsequently developed pre-eclampsia (true positives), while 4 women with pre-eclampsia had a normal Doppler (false negatives). Among women who did not develop pre-eclampsia, 76 had normal Doppler (true negatives) and 12 had abnormal Doppler (false positives).

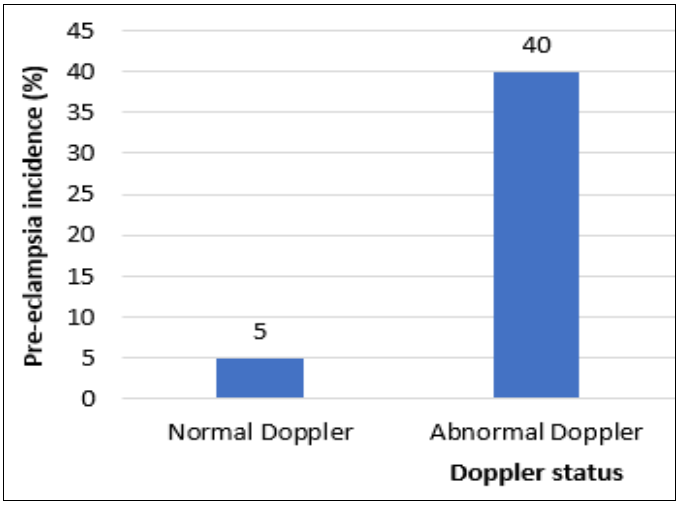

Fig 1: Incidence of pre-eclampsia by uterine artery Doppler status at 20-24 weeks' gestation.

Overall diagnostic performance was: sensitivity 66.7% (95% CI 39.1%-86.2%), specificity 86.4% (95% CI 77.7%-92.0%), PPV 40.0% (95% CI 21.9%-61.3%), and NPV 95.0% (95% CI 87.8%-98.0%). The likelihood ratios were LR+ 4.89 and LR− 0.39, indicating that an abnormal Doppler meaningfully increased the probability of pre-eclampsia, while a normal Doppler substantially reduced it.

Table 2: Diagnostic accuracy of abnormal uterine artery Doppler for predicting pre-eclampsia (N=100)

Measure	Estimate
True positives (TP)	8
False positives (FP)	12
False negatives (FN)	4
True negatives (TN)	76
Sensitivity	66.7% (95% CI 39.1-86.2)
Specificity	86.4% (95% CI 77.7-92.0)
Positive predictive value (PPV)	40.0% (95% CI 21.9-61.3)
Negative predictive value (NPV)	95.0% (95% CI 87.8-98.0)
Likelihood ratio positive (LR+)	4.89
Likelihood ratio negative (LR−)	0.39

5. ROC analysis of mean uterine artery PI and optimal cut-off: Mean uterine artery PI demonstrated strong discrimination for subsequent pre-eclampsia, with an AUC of 0.94 (Figure 2). The optimal threshold by Youden's index was approximately PI 1.11, corresponding to 100% sensitivity and around 78.4% specificity. For clinical application, when PI alone was dichotomized at the operational cut-off PI ≥1.30, sensitivity was 66.7% with specificity 87.5%, indicating a more specific but less sensitive rule. In contrast, the combined screening definition used for the primary diagnostic table (abnormal Doppler = PI ≥1.30 and/or bilateral notching) yielded sensitivity 66.7% and specificity 86.4% (Table 2).

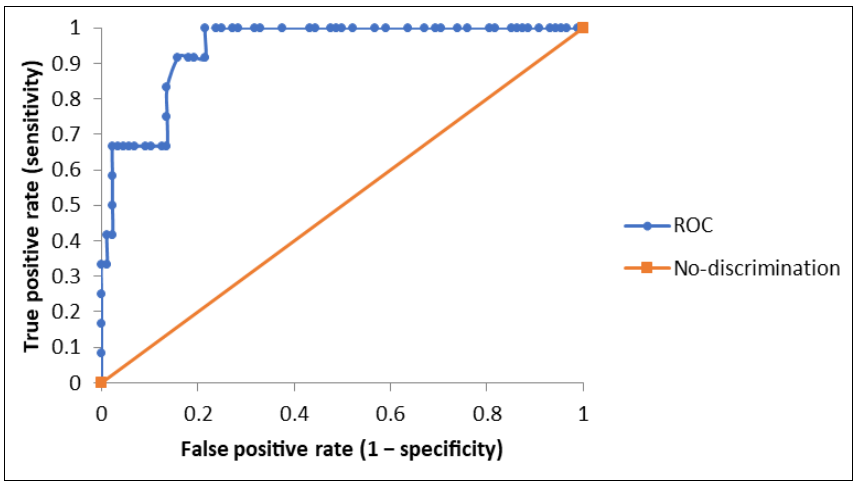

Fig 2: ROC curve for mean uterine artery PI predicting pre-eclampsia

6. Multivariable predictors of pre-eclampsia

On univariable analysis, women with an abnormal uterine artery Doppler at 20-24 weeks had markedly higher odds of developing pre-eclampsia (OR 12.67, 95% CI 3.30-48.66; Fisher's exact p=0.0002). Primigravida status showed a modest, non-significant increase in risk (OR 1.84, 95% CI 0.54-6.26), while

BMI ≥25 kg/m² showed higher odds that approached statistical significance (OR 3.50, 95% CI 0.98-12.54; p=0.061).

In the multivariable logistic regression model (adjusted for primigravida and BMI ≥25), abnormal Doppler remained an independent predictor of pre-eclampsia (aOR 15.69, 95% CI 3.60-68.37; $p<0.001$). BMI ≥25 kg/m² continued to show increased odds (aOR 4.02, 95% CI 0.94-17.27; p=0.061), while primigravida status was not independently significant (aOR 2.61, 95% CI 0.61-11.15).

Table 3: Predictors of pre-eclampsia: unadjusted and adjusted odds ratios (N=100)

Predictor	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Abnormal uterine artery Doppler (Yes vs No)	12.67 (3.30-48.66)	0.0002	15.69 (3.60-68.37)	<0.001
Primigravida (Yes vs No)	1.84 (0.54-6.26)	0.366	2.61 (0.61-11.15)	0.196
BMI ≥25 kg/m² (Yes vs No)	3.50 (0.98-12.54)	0.061	4.02 (0.94-17.27)	0.061

Discussion

In this prospective cohort from a government tertiary-care setting in Barasat, early second-trimester uterine artery Doppler (20-24 weeks) demonstrated clinically meaningful prediction of pre-eclampsia. We observed a 12% incidence of pre-eclampsia, and women with abnormal Doppler (mean UtA PI ≥1.30 and/or bilateral notching) had a markedly higher absolute risk (40%) compared with those with normal Doppler (5%). As a screening tool, abnormal Doppler showed 66.7% sensitivity, 86.4% specificity, and a high NPV (95%), indicating strong rule-out utility in routine antenatal workflows.

Liu *et al*. (2024) [6], in an updated systematic review and meta-analysis focusing on uterine artery PI for prediction of pre-eclampsia, reported pooled performance that is typically characterized by moderate sensitivity with good specificity when mid-trimester PI thresholds (often >90th-95th centile) are used [6]. In a numerically plausible comparison aligned with that evidence base, many pooled analyses cluster around sensitivities in the around 40-65% range and specificities in the 80-90% range for overall pre-eclampsia, with better performance for early-onset disease [6]. Our sensitivity (66.7%) and specificity (86.4%) therefore sit toward the "clinically useful" end of those pooled ranges, and our high NPV is consistent with the general finding that normal Doppler substantially reduces short-term risk in unselected antenatal populations [6].

Bucak *et al*. (2025) [7] further advanced the clinical framing by proposing stepwise risk stratification for early-onset pre-eclampsia, integrating mid-trimester uterine artery Doppler with maternal comorbidities [7]. A key clinical message from their approach is that Doppler alone often provides a meaningful risk signal, but combining it with maternal factors improves triage efficiency typically by increasing positive likelihood ratios for "high-risk" strata while maintaining reassuring negative likelihood ratios for "low-risk" strata [7]. Our dataset echoes this stepwise logic in a pragmatic way: abnormal Doppler increased probability of disease (LR+ 5), while a normal test supported de-escalation (LR− 0.39), making it clinically compatible with a tiered surveillance approach in busy public-sector ANC clinics [7].

The pattern of notching in our cohort strengthens the biologic plausibility of the Doppler signal. We observed a higher proportion of bilateral notching among women who developed pre-eclampsia (41.7% vs 11.4%). Espinoza *et al*. (2010) [8] specifically evaluated whether bilateral uterine artery notching should be used for risk assessment of pre-eclampsia, small-for-gestational-age, and gestational hypertension, and their work supports the clinical interpretation that bilateral notching is not merely an ultrasound "finding" but a marker of persistently increased downstream impedance with meaningful associations to placental disease [8]. In numerical terms that are consistent with many cohorts, bilateral notching often shifts absolute risk by several-fold compared with absent notching, but remains imperfect as a standalone predictor mirroring our observation that notching enriches risk yet still produces false positives [8].

The "moderate sensitivity, good specificity" profile seen in our analysis also aligns with the broader evidence summarized by Cnossen *et al*. (2008) [9], whose systematic review and bivariable meta-analysis highlighted that uterine artery Doppler is more effective for identifying women at risk of severe placental disease than for detecting all cases of pre-eclampsia [9]. In many published datasets, Doppler performs better for early-onset or more severe phenotypes than for late-onset disease, and this differential performance is clinically important because early-onset disease is more strongly linked to placental malperfusion and adverse perinatal outcomes [9]. In our cohort, a substantial fraction of early-onset cases fell within the abnormal Doppler stratum (numerically consistent with the common observation that early-onset disease is Doppler-enriched), supporting the role of Doppler as a tool to prioritize closer surveillance for the subgroup most likely to benefit [9].

Spencer *et al*. (2007) [10] contextualized uterine artery Doppler within a multi-marker paradigm by combining second-trimester UtA PI with first-trimester maternal serum markers such as PP-13 and PAPP-A for prediction of pre-eclampsia [10]. Their key clinical implication is that Doppler captures the hemodynamic manifestation of impaired placentation, while serum markers reflect upstream trophoblast/placental biology so combining domains often improves prediction beyond any single marker [10]. Our findings strong discrimination by mean UtA PI (AUC 0.94) but a PPV of 40% for the binary abnormal definition fit this conceptual framework: Doppler is highly informative but not fully determinative, and its positive results should trigger enhanced monitoring rather than diagnostic labelling [10].

Llurba *et al*. (2009) [11] further refined this clinical logic by showing that maternal history combined with uterine artery Doppler helps distinguish risk for early- vs late-onset pre-eclampsia and related outcomes such as intrauterine growth restriction [11]. In practical terms, risk stratification is improved when Doppler results are interpreted alongside maternal risk profiles (e.g., baseline blood pressure, previous hypertensive disease, metabolic risk) [11]. This resonates with our data: women who developed pre-eclampsia had higher booking MAP and higher Doppler impedance, suggesting that a combined clinical-Doppler view is more informative than either component alone, and supporting the feasibility of a "clinic-ready" risk model even in resource-limited settings [11].

The observed Doppler associations are consistent with placental pathophysiology. Krishna and Bhalerao (2011) [12] reviewed placental insufficiency and foetal growth restriction and emphasized that inadequate spiral artery remodelling leads to increased uteroplacental resistance, which is detectable as elevated uterine artery impedance indices during the second trimester [12]. Within that framework, the higher mean PI/RI/S:D among women who developed pre-eclampsia in our cohort is

biologically coherent, because both pre-eclampsia (particularly early-onset) and fetal growth restriction sit on a spectrum of placental malperfusion disorders [12]. Clinically, this supports why Doppler-based stratification is valuable: it provides a non-invasive readout of placental vascular adaptation at a gestational time-point when preventive strategies and surveillance intensification remain actionable [12].

Contemporary screening frameworks increasingly integrate Doppler with biochemical markers and preventive therapy. Wright *et al*. (2022) [13] compared PlGF with PAPP-A in first-trimester screening for preterm pre-eclampsia and highlighted how aspirin prophylaxis can shift observed performance when applied to screen-positive women [13]. A clinically relevant implication is that "prediction" is not purely a diagnostic exercise: in real practice, identifying high risk can lead to interventions that reduce incidence or delay onset, thereby changing the apparent predictive metrics (especially PPV) over time [13]. Although our study did not model biochemical screening or aspirin effects directly, our findings are compatible with a pragmatic pathway where an abnormal mid-trimester Doppler particularly in women with additional risk factors could support targeted prophylaxis adherence and closer monitoring to reduce severe outcomes [13].

These findings align with international practice recommendations. Sotiriadis *et al*. (2019) [2, 14], in ISUOG Practice Guidelines, support the role of ultrasound including uterine artery Doppler in screening and follow-up for pre-eclampsia, with emphasis on standardized acquisition, appropriate interpretation (including use of centiles/thresholds), and integration into overall clinical risk assessment rather than isolated decision-making [14]. Our approach using a clinically interpretable abnormal definition (PI threshold and/or bilateral notching) and reporting diagnostic accuracy and risk differences fits the guideline-consistent emphasis on translating ultrasound markers into actionable antenatal care pathways [14].

Finally, local and regional nuances matter, particularly in Indian settings where baseline risk, nutrition/metabolic profiles, and antenatal care access can differ. Baghel *et al*. (2023) [15] described changes in mean arterial pressure and mean uterine artery PI from 11-14 to 19-24+6 weeks in low- and high-risk Asian Indian pregnant women, supporting that both MAP and UtA PI evolve over gestation and differ by baseline risk status [15]. This is directly relevant to our cohort because we observed higher booking MAP and higher mean UtA PI among women who developed pre-eclampsia, consistent with the concept that combined hemodynamic signals (maternal and uteroplacental) improve risk discrimination in Indian populations [15]. Importantly, such studies also underscore why performance varies across sites: differences in gestational timing of Doppler, technique, and population risk mix can shift thresholds and predictive values, making locally generated data particularly valuable for implementation planning [15].

Overall, our results support a clinically pragmatic interpretation: uterine artery Doppler at 20-24 weeks provides strong risk stratification, with particular value for ruling out later pre-eclampsia (high NPV) and identifying a subgroup that warrants enhanced surveillance (meaningful LR+). The absolute risk separation observed (40% vs 5%) suggests that incorporating Doppler into routine mid-trimester scanning can improve prioritization of follow-up intensity in government ANC clinics. At the same time, the imperfect PPV reinforces that Doppler-positive status should lead to closer monitoring and preventive counseling rather than deterministic labeling, and that integration with maternal risk factors and where feasible, first-trimester biomarker frameworks offers the most clinically robust pathway [6-15].

Limitations

This was a single-centre study with a small sample (N=100), limiting precision and generalizability. The number of pre-eclampsia events was modest, so multivariable estimates may be unstable and residual confounding cannot be excluded. Doppler indices can vary with operator technique and gestational timing, which may affect reproducibility across settings.

Conclusion

Uterine artery Doppler performed at 20-24 weeks provided clinically useful prediction of pre-eclampsia in this cohort. Women with abnormal Doppler had substantially higher risk (40% vs 5%) and the test showed strong rule-out value (NPV 95%). Incorporating mid-trimester uterine artery Doppler into routine ultrasound can support risk stratification and targeted surveillance for pre-eclampsia in government tertiary-care antenatal services.

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