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Original Research Article

Diagnostic Accuracy of First-Trimester Uterine Artery Pulsatility Index in Predicting Preeclampsia Among Primigravida

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Abstract: *Preeclampsia (PE) remains a major cause of maternal and perinatal morbidity and mortality worldwide. Early prediction using first-trimester uterine artery pulsatility index (UtA-PI) has been proposed to identify women at risk, but its diagnostic performance in low-risk primigravidae remains uncertain.* ***Objective:*** *To evaluate the diagnostic accuracy of first-trimester mean UtA-PI for predicting PE among primigravidae and to describe associated maternal and neonatal outcomes.* ***Methods:*** *We conducted a prospective diagnostic-accuracy study in primigravida women at 11+0–13+6 weeks. Bilateral UtA Doppler was performed and mean UtA-PI and MoM were recorded. Participants were followed to delivery; PE was ascertained using standard criteria. Group comparisons used Welch's t-test for continuous variables and chi-square/Fisher's exact tests for categorical variables. Diagnostic accuracy was assessed using a predefined threshold (UtA-PI MoM ≥2.5) and receiver operating characteristic (ROC) analysis.* ***Results:*** *Of 160 women, 8 (5.0%) developed PE. Baseline characteristics were similar between groups, except higher pre-scan diastolic BP in women who later developed PE (76.88 ± 4.22 vs 71.88 ± 8.23 mmHg; p = 0.0121). First-trimester mean UtA-PI and MoM were not significantly different between PE and non-PE groups (both p > 0.39). Peak SBP/DBP during pregnancy were higher in PE (141.38 ± 12.35 vs 121.68 ± 11.22 mmHg, p = 0.0025; 104.38 ± 6.25 vs 76.78 ± 8.87 mmHg, p < 0.0001). Using UtA-PI MoM ≥2.5, there were 0 true positives, 0 false positives, 8 false negatives, and 152 true negatives (sensitivity 0.0%, specificity 100.0%, NPV 95.0%, accuracy 95.0%). ROC analysis for mean UtA-PI MoM showed limited discrimination (AUC = 0.585).* ***Conclusions:*** *In this primigravida cohort, first-trimester mean UtA-PI demonstrated limited standalone predictive value for PE, while adverse maternal hemodynamics and neonatal outcomes were evident among PE cases. Screening strategies should consider gestational-age–specific centiles and integration with clinical/biochemical markers rather than UtA-PI alone.*

Keywords: Pregabalin, Hemodynamics, Pneumoperitoneum

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Introduction

Preeclampsia (PE) complicates ~2–8% of pregnancies worldwide and remains a major driver of maternal and perinatal morbidity and mortality, particularly in low- and middle-income settings (1,2). Primigravida women are at heightened risk, and timely identification of those likely to develop PE enables preventive strategies such as low-dose aspirin and closer surveillance (3,4). The uterine artery pulsatility index (UtA-PI), measured non-invasively by Doppler between 11 and 14 weeks, reflects impedance to utero-placental perfusion and is pathophysiologically linked to impaired trophoblastic remodeling of the spiral arteries, the hallmark of PE (4,5).

Large prospective cohorts and meta-analyses show that first-trimester UtA-PI, alone or combined with maternal risk factors/biochemical markers, can achieve sensitivities of ~60–85% for early-onset PE at a ~10% false-positive rate, with area under the ROC curve (AUC) commonly in the 0.70–0.85 range (1–4,6). For example, routine-care screening using UtA-PI plus clinical factors yielded robust diagnostic performance in a real-world setting (1), while a recent systematic review confirmed independent predictive value of UtA-PI across diverse populations (4). Cohort data also link elevated first-trimester UtA-PI to adverse maternal and neonatal outcomes, including higher rates of severe hypertension, fetal growth restriction (FGR), preterm delivery, and NICU admission (6–8). A 2023 study reported that abnormal UtA-PI was associated with increased risks of maternal complications and low birthweight (6). Conversely, when UtA-PI is integrated with maternal characteristics, prediction improves further, supporting a precision-screening paradigm (5,).

Despite promising accuracy, implementation challenges persist. Cut-off selection varies (percentile-based vs. multiples of the median, MoM), local calibration is seldom performed, and most reference ranges come from Caucasian-predominant cohorts (4). In South-Asian primigravida populations, context-specific estimates are limited, hampering generalisability of thresholds, resource planning, and cost-effectiveness. Moreover, while second-trimester Doppler also predicts PE and small-for-gestational-age fetuses, the first trimester presents the best window for prophylaxis (e.g., aspirin before 16 weeks) and risk-stratified antenatal care (3,).

Given the burden of PE and the opportunity for early intervention, there is a clear need to establish population-specific diagnostic accuracy of first-trimester mean UtA-PI in primigravida women, including sensitivity, specificity, predictive values, and AUC, alongside locally optimised cut-offs. Such evidence can guide screening algorithms and inform aspirin prophylaxis pathways to reduce PE-related morbidity and mortality in the region (3-5).

The objective of the study is to determine the sensitivity, specificity, positive and negative predictive values, and AUC of first-trimester mean UtA-PI for predicting preeclampsia in primigravida women.

Methodology

We conducted a prospective diagnostic-accuracy cohort at a tertiary centre KRL Hospital islamabad over six months from 1st august 2024 till 31st January 2025,following ethical approval. Consecutive primigravida women with singleton, viable pregnancies were enrolled at 11 + 0 to 13 + 6 weeks (confirmed by crown-rump length). We excluded chronic

hypertension, renal disease, diabetes or autoimmune disorders, multiple pregnancy, major fetal anomalies, and inadequate Doppler image quality. After written informed consent, baseline demographics, residence, vitals, and risk factors (family history of PE, thyroid disease, smoking, and consanguinity) were recorded. Transabdominal colour Doppler (3.5–5 MHz) was performed with the uterine arteries identified at the cervicocervical junction. With an insonation angle <30°, three uniform waveforms were acquired on each side and the device-calculated left and right UtA-PI were obtained; their mean was recorded. Mean UtA-PI was converted to MoM using gestational-age-appropriate reference charts. An "abnormal" result was pre-specified as ≥95th percentile (≈2.5 MoM); the optimal cut-off was subsequently refined by ROC analysis. Operators followed a technique checklist; inadequate images were documented and excluded. Participants received routine antenatal care and were followed until delivery. Treating clinicians, blinded to Doppler results, ascertained PE according to ISSHP-2023 criteria and classified onset as early (<34 weeks) or late (≥34 weeks). Delivery details (gestational age, mode), maternal complications (eclampsia, HELLP, abruption, ICU, AKI, hepatic dysfunction), and neonatal outcomes (sex, birthweight, Apgar scores, NICU admission, FGR, stillbirth/neonatal death) were recorded prospectively. Data were double-entered into a spreadsheet. Analyses (SPSS v29) summarised continuous variables as mean±SD and categorical variables as n (%). Diagnostic accuracy metrics (sensitivity, specificity, PPV, NPV) and ROC/AUC were calculated using 2×2 tables, two-sided p<0.05 denoted statistical significance.

Results

Among 160 primigravidae, the mean age was 25.33 ± 3.96 years; women who developed preeclampsia (PE, n = 8) were similar in age to those without PE (26.25 ± 3.01 vs 25.28 ± 4.01 years, p = 0.4093). Mean height and weight were 159.89 ± 6.97 cm and 65.58 ± 9.81 kg overall; corresponding values in the PE vs no-PE groups were 164.30 ± 9.17 vs 159.66 ± 6.80 cm (p = 0.1987) and 69.29 ± 13.23 vs 65.39 ± 9.61 kg (p = 0.4366). BMI averaged 25.78 ± 4.42 kg/m² with no between-group difference (25.80 ± 5.42 vs 25.78 ± 4.38 kg/m², p = 0.9932). Most participants resided in urban areas (70.6%; rural 29.4%), with similar distribution across PE (urban 75.0%, rural 25.0%) and no-PE groups (urban 70.4%, rural 29.6%; p = 1.000). Regarding risk factors, consanguinity was present in 18.1% overall (25.0% PE vs 17.8% no-PE, p = 0.6371), smoking in 3.8% (0.0% vs 3.9%, p = 1.0000), thyroid disease in 6.9% (25.0% vs 5.9%, p = 0.0960), and family history of PE in 6.9% (12.5% vs 6.6%, p = 0.4419).

Clinically, baseline (pre-scan) systolic blood pressure (SBP) averaged 114.56 ± 11.01 mmHg and was numerically lower in PE (108.25 ± 13.50 vs 114.89 ± 10.82 mmHg, p = 0.2106), while baseline diastolic BP (DBP) was higher in PE (76.88 ± 4.22 vs 71.88 ± 8.23 mmHg, p = 0.0121). Pulse rate and crown-rump length were comparable (80.50 ± 11.58 vs 83.59 ± 9.50 bpm, p = 0.4813; 64.97 ± 10.99 vs 66.09 ± 10.30 mm, p = 0.7865). First-trimester uterine artery Dopplers showed no statistically significant differences: left UtA-PI 1.84 ± 0.54 vs 1.68 ± 0.48 (p = 0.4354), right UtA-PI 1.87 ± 0.61 vs 1.67 ± 0.42 (p = 0.3864), mean UtA-PI 1.85 ± 0.56 vs 1.67 ± 0.41 (p = 0.3921), and mean UtA-PI MoM 1.16 ± 0.35 vs 1.05 ± 0.25 (p = 0.4010). The highest recorded SBP and DBP during pregnancy were markedly greater in the PE group (141.38 ± 12.35 vs 121.68 ± 11.22 mmHg, p = 0.0025; and 104.38 ± 6.25 vs 76.78 ± 8.87 mmHg, p < 0.0000).

Neonatal outcomes showed lower birthweight in PE (2572.88 ± 401.33 vs 3005.74 ± 419.09 g, p = 0.0184), with non-significant trends to lower Apgar scores at 1 and 5 minutes (7.50 ± 1.31 vs 8.34 ± 1.05, p = 0.1164; 8.62 ± 0.92 vs 9.27 ± 0.85, p = 0.0890). Left uterine artery notching was more frequent in PE (37.5% vs 7.2%, p = 0.0232), while right-sided notching did not differ (0.0% vs 10.5%, p = 1.0000). All participants were reported as having "abnormal MoM ≥ 2.5" (100% in both groups, p = 1.0000). Mode of delivery distribution did not differ significantly (caesarean 62.5% vs 34.9%; instrumental 0.0% vs 8.6%; vaginal 37.5% vs 56.6%; p = 0.2488). NICU admission was higher in PE (37.5% vs 7.2%, p = 0.0232), whereas FGR/IUGR (0.0% vs 5.3%), stillbirth (0.0% vs 0.7%), and neonatal death (0.0% vs 0.7%) were rare with non-significant differences (all p = 1.0000). Neonatal sex distribution was similar (female 37.5% vs 45.4%; male 62.5% vs 54.6%; p = 0.7310).

Using a diagnostic threshold of UtA-PI MoM ≥ 2.5, the 2×2 table yielded 0 true positives, 0 false positives, 8 false negatives, and 152 true negatives, corresponding to a sensitivity of 0.0%, specificity of 100.0%, non-estimable PPV (no positive tests), NPV of 95.0%, and overall accuracy of 95.0%. The ROC curve for mean UtA-PI MoM demonstrated limited discrimination with an AUC of 0.585 (Figure 1).

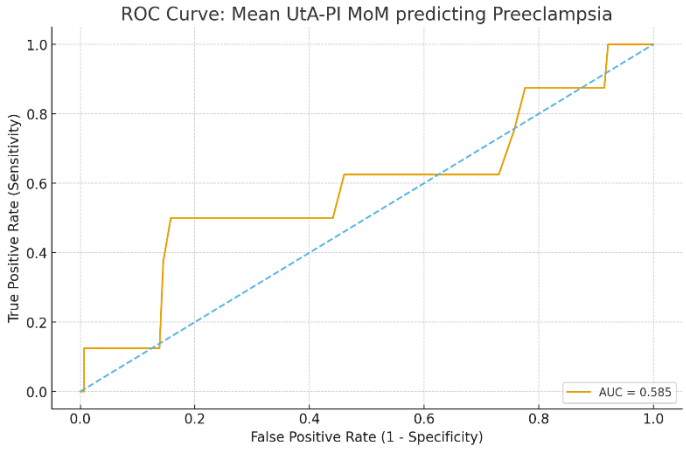

Figure 1: ROC curve with an AUC value of 0.585.

Table 1: Demographic Variables

Variable	Overall (n=160)	PE (n=8)	No PE (n=152)	P value
Age (yrs)	25.33 ± 3.96	26.25 ± 3.01	25.28 ± 4.01	0.4093
Height (cm)	159.89 ± 6.97	164.30 ± 9.17	159.66 ± 6.80	0.1987
Weight (kg)	65.58 ± 9.81	69.29 ± 13.23	65.39 ± 9.61	0.4366
BMI (Kg/m^2)	25.78 ± 4.42	25.80 ± 5.42	25.78 ± 4.38	0.9932
Residence				1.000
Rural	47 (29.4%)	2 (25.0%)	45 (29.6%)	
Urban	113 (70.6%)	6 (75.0%)	107 (70.4%)	
Risk Factors				
Consanguinity	29 (18.1%)	2 (25.0%)	27 (17.8%)	0.6371
Smoking	6 (3.8%)	0 (0.0%)	6 (3.9%)	1.0000
Thyroid	11 (6.9%)	2 (25.0%)	9 (5.9%)	0.0960
Family PE	11 (6.9%)	1 (12.5%)	10 (6.6%)	0.4419

Table 2: Maternal clinical variables

Variable	Overall (n=160)	PE (n=8)	No PE (n=152)	P Value
PreScan SBP	114.56 ± 11.01	108.25 ± 13.50	114.89 ± 10.82	0.2106
PreScan DBP	72.13 ± 8.15	76.88 ± 4.22	71.88 ± 8.23	0.0121
Pulse (bpm)	83.43 ± 9.59	80.50 ± 11.58	83.59 ± 9.50	0.4813
CRL (mm)	66.03 ± 10.30	64.97 ± 10.99	66.09 ± 10.30	0.7865
Left UtA-PI	1.69 ± 0.48	1.84 ± 0.54	1.68 ± 0.48	0.4354
Right UtA-PI	1.68 ± 0.43	1.87 ± 0.61	1.67 ± 0.42	0.3864
Mean-UtA-PI	1.68 ± 0.42	1.85 ± 0.56	1.67 ± 0.41	0.3921
Mean-UtA-MoM	1.05 ± 0.26	1.16 ± 0.35	1.05 ± 0.25	0.4010
Highest SBP	122.66 ± 12.04	141.38 ± 12.35	121.68 ± 11.22	0.0025
Highest DBP	78.16 ± 10.62	104.38 ± 6.25	76.78 ± 8.87	<0.0000

Table 3: Neonatal parameters

Variable	Overall (n=160)	PE (n=8)	No PE (n=152)	P value
Birthweight (g)	2984.09 ± 427.61	2572.88 ± 401.33	3005.74 ± 419.09	0.0184
Apgar 1min	8.29 ± 1.07	7.50 ± 1.31	8.34 ± 1.05	0.1164
Apgar 5min	9.24 ± 0.86	8.62 ± 0.92	9.27 ± 0.85	0.0890
Notching Left	14 (8.8%)	3 (37.5%)	11 (7.2%)	0.0232
Notching Right	16 (10.0%)	0 (0.0%)	16 (10.5%)	1.0000
Abnormal MoM ge 2p5	160 (100.0%)	8 (100.0%)	152 (100.0%)	1.0000
Delivery Mode				0.2488
Caesarean	58 (36.2%)	5 (62.5%)	53 (34.9%)	
Instrumental	13 (8.1%)	0 (0.0%)	13 (8.6%)	
Vaginal	89 (55.6%)	3 (37.5%)	86 (56.6%)	
NICU	14 (8.8%)	3 (37.5%)	11 (7.2%)	0.0232
FGR IUGR	8 (5.0%)	0 (0.0%)	8 (5.3%)	1.0000
Stillbirth	1 (0.6%)	0 (0.0%)	1 (0.7%)	1.0000
Neonatal Death	1 (0.6%)	0 (0.0%)	1 (0.7%)	1.0000
Neonatal Sex				0.7310
Female	72 (45.0%)	3 (37.5%)	69 (45.4%)	
Male	88 (55.0%)	5 (62.5%)	83 (54.6%)	

Table 4: 2x2 accuracy table

	Test + (UtA-PI MoM ≥2.5)	Test - (UtA-PI MoM <2.5)
Outcome + (PE)	0	8
Outcome - (No PE)	0	152
Sensitivity		0.0%
Specificity		100.0%
PPV		—
NPV		95.0%
Accuracy		95.0%

Discussion

In this primigravida cohort (n=160), first-trimester uterine artery Doppler showed limited discriminatory ability for preeclampsia (PE): AUC 0.585, no cases above the dichotomous MoM cut-off, and consequently 0% sensitivity with 100% specificity. Diastolic pressure was modestly higher at booking in those who later developed PE, and downstream maternal (peak SBP/DBP) and neonatal outcomes (lower birthweight, higher NICU admission) were worse among PE cases, patterns consistent with the clinical phenotype of placental disease.

Our findings align with large evidence syntheses showing that UtA-PI alone is a specific but only modestly sensitive early screen, particularly for all-comers rather than early-onset disease. Cnossen et al. reported high specificity and low pooled sensitivity for PE prediction using UtA Doppler across diverse studies, while Velauthar et al. confirmed that first-trimester UtA Doppler is most informative for early-onset PE, with moderate sensitivity and high specificity. These meta-analyses help explain the weak standalone performance observed here (AUC ≈0.59). (7,8)

A key driver of our near-zero sensitivity was the very stringent threshold (MoM ≥ 2.5). Gestation-specific centile-based thresholds (e.g., ≥95th percentile) are typically recommended because UtA-PI falls with advancing gestation and must be normalized to reference ranges; using an extreme fixed MoM cut-off will miss most later PE. Gómez et al. provided widely used reference charts underpinning MoM standardization, and contemporary guidance emphasizes risk models that transform raw PI to MoM and apply centiles rather than absolute high MoM gates. (9,10)

The higher rate of uterine artery notching among women who developed PE in our data echoes prior reports that incorporate notching with PI to improve discrimination, although its incremental value over PI alone is variable across studies and populations. (7)

Consistent with modern practice, the literature indicates that combining UtA-PI with maternal factors and other markers performs far better than UtA-PI alone. The FMF first-trimester "triple test" (maternal factors +

mean arterial pressure + UtA-PI + PlGF) achieves ~75–90% detection for preterm/early PE at a 10% false-positive rate and has been externally validated, while biomarker-only or Doppler-only strategies are inferior. (10,11,12) Moreover, adding second-trimester Doppler or considering bilateral notching further enhances identification in nulliparas, and large development studies at 11–13 weeks show that integrated models can detect >80% of early PE. (13, 14).

The adverse neonatal profile we observed (lower birthweight, more NICU admissions) is in line with the established association of PE with fetal growth restriction and neonatal morbidity, reflecting placental malperfusion downstream of defective spiral artery remodeling. (8, 15).

Overall, our study reinforces three practical lessons for a primigravida screening program: (i) avoid overly conservative absolute MoM cut-offs and use GA-specific centiles after MoM standardization; (ii) adopt combined first-trimester risk algorithms (maternal factors ± MAP ± PlGF ± UtA-PI) rather than UtA-PI alone; and (iii) consider a two-step approach that revisits Doppler in the mid-trimester for women at intermediate risk. Methodological limitations of our dataset especially the very low number of PE events (n=8) and a single fixed, extreme Doppler threshold likely widened uncertainty and depressed apparent performance compared with the literature. Future work should locally calibrate MoMs, predefine centile cut-offs (e.g., ≥95th), and integrate MAP/PlGF within validated competing-risks frameworks. (10, 13, 16).

Conclusion

First-trimester mean uterine artery PI had limited discriminatory value for preeclampsia in primigravidae (AUC ≈ 0.585) and, at a stringent MoM cut-off, produced 0% sensitivity with 100% specificity. PE was associated with higher downstream blood pressures, lower birthweight, and more NICU admissions, reflecting greater placental disease burden. As a stand-alone screen, UtA-PI is insufficient; GA-specific centiles and multivariable algorithms (maternal factors ± MAP ± biomarkers) should be preferred. Larger, locally calibrated studies are needed to optimize thresholds and prospectively validate combined first-trimester screening pathways in this population.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-24)

Consent for publication
Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

SEZ (Post Graduate Resident)
Manuscript drafting, Study Design,
MMK (Assistant Professor)
Review of Literature, Data entry, Data analysis, and drafting article.
MWA (Associate Professor)
Conception of Study, Development of Research Methodology Design,
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Manuscript drafting, Study Design,
SI (Consultant Radiologist)
Review of Literature, Data entry, Data analysis, and drafting article.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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