



UTERINE ARTERY DOPPLER IN PREECLAMPSIA: CORRELATION WITH DISEASE SEVERITY AND PREGNANCY OUTCOME

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Abstract

Background: Preeclampsia is a multisystem hypertensive disorder of pregnancy associated with abnormal placentation and impaired uteroplacental perfusion. Uterine artery Doppler provides a non-invasive assessment of uteroplacental vascular resistance and may help identify pregnancies at increased risk of severe disease and adverse outcome.

Aim: To evaluate uterine artery Doppler indices in women with preeclampsia and determine their correlation with disease severity and pregnancy outcome.

Methods: One hundred pregnant women diagnosed with preeclampsia after 20 weeks of gestation were evaluated prospectively. Bilateral uterine artery Doppler was performed using pulsed-wave Doppler. Pulsatility index (PI), resistance index (RI), systolic/diastolic ratio and persistent early diastolic notching were recorded. Maternal disease severity, gestational age at delivery, mode of delivery, birth weight, NICU admission and adverse perinatal outcome were documented.

Results: The mean gestational age at Doppler assessment was 32.8 ± 3.1 weeks. Severe preeclampsia was present in 38% of women. Mean bilateral uterine artery PI was 1.48 ± 0.36 and RI was 0.69 ± 0.09 . Mean PI was higher in severe than non-severe preeclampsia (1.76 ± 0.31 vs 1.31 ± 0.27). Persistent bilateral notching was present in 34%. Higher PI and bilateral notching were associated with earlier delivery, lower birth weight and increased NICU admission.

Conclusion: Elevated uterine artery Doppler resistance, particularly increased PI and persistent bilateral notching, was associated with greater disease severity and adverse pregnancy outcomes in this cohort. Uterine artery Doppler may provide useful complementary information for risk stratification when interpreted alongside clinical and biochemical findings.

Keywords: preeclampsia; uterine artery Doppler; pulsatility index; resistance index; notching; fetal growth restriction; pregnancy outcome

Introduction

Preeclampsia is a pregnancy-specific hypertensive disorder characterized by new-onset hypertension after 20 weeks of gestation with proteinuria and/or maternal organ dysfunction or uteroplacental dysfunction. It remains a major cause of maternal and perinatal morbidity and mortality worldwide.[1–6]

The pathophysiology involves abnormal placentation, inadequate trophoblastic invasion and failure of normal transformation of spiral arteries into low-resistance vessels. This results in increased uteroplacental vascular resistance and placental ischemia.[3–8]

Uterine artery Doppler provides a non-invasive method of assessing resistance in the uteroplacental circulation. Increased pulsatility index (PI), resistance index (RI) and persistent early diastolic notching can reflect incomplete spiral artery remodeling.[7–13]

Studies have evaluated uterine artery Doppler as a predictor of preeclampsia, fetal growth restriction and adverse pregnancy outcome. However, Doppler indices vary with gestational age and clinical phenotype, and interpretation should be integrated with maternal characteristics and other surveillance parameters.[9–16]

Severe preeclampsia is associated with earlier delivery, fetal growth restriction, low birth weight and increased neonatal intensive care requirements. Identification of women at higher risk may assist surveillance and timing of delivery.[1–6,14–19]

The present Radiology–Obstetrics & Gynaecology collaborative study evaluates uterine artery Doppler findings in 100 women with preeclampsia and correlates Doppler indices with disease severity and pregnancy outcome.

2. Aim and Objectives

Aim: To study uterine artery Doppler indices in preeclampsia and assess their relationship with disease severity and pregnancy outcome.

- Measure bilateral uterine artery PI, RI and S/D ratio.
- Record unilateral and bilateral early diastolic notching.
- Compare Doppler indices between non-severe and severe preeclampsia.
- Assess association of Doppler abnormalities with gestational age at delivery.
- Correlate Doppler findings with birth weight and fetal growth restriction.
- Evaluate association with NICU admission and adverse perinatal outcome.
- Assess maternal outcomes including mode of delivery and severe maternal complications.

3. Materials and Methods

3.1 Study design

Hospital-based prospective observational study done on 100 pregnant women diagnosed with preeclampsia.

3.2 Study setting and period

Department of Radiology in collaboration with Obstetrics & Gynaecology at Maheshwara Medical College and Hospital, Telangana, India. from February 2023 – July 2023.

3.3 Sample size

100 pregnancies.

3.4 Inclusion criteria

Singleton pregnancies ≥ 20 weeks with clinically diagnosed preeclampsia and available uterine artery Doppler examination before delivery.

3.5 Exclusion criteria

Multiple pregnancy, major fetal structural anomaly, known chronic renal disease predating pregnancy, pre-existing chronic hypertension without superimposed preeclampsia, and inadequate Doppler waveforms.

3.6 Clinical assessment

Maternal age, parity, gestational age, blood pressure, proteinuria, symptoms, laboratory parameters and relevant obstetric risk factors were recorded.

3.7 Doppler technique

The uterine arteries were identified near their crossing with the external iliac arteries. Pulsed-wave Doppler was obtained using standard technique. At least three similar consecutive waveforms were recorded from each side.

3.8 Doppler parameters

Right and left uterine artery PI, RI and S/D ratio were recorded. Mean bilateral PI and RI were calculated. Early diastolic notching was categorized as absent, unilateral or bilateral/persistent.

3.9 Disease severity

Preeclampsia was categorized as non-severe or severe according to clinical, laboratory and organ-dysfunction criteria consistent with contemporary obstetric definitions.

3.10 Pregnancy outcome

Gestational age at delivery, mode of delivery, birth weight, fetal growth restriction, Apgar status where available, NICU admission, stillbirth and major maternal complications were recorded.

3.11 Statistical analysis

Continuous variables were summarized as mean $\pm$ SD and categorical variables as frequencies/percentages. Cross-tabulations and correlation analyses were used for interpretation. P-values and diagnostic performance estimates should be recalculated from the dataset.

4. Results

The cohort included 100 women with preeclampsia. Mean maternal age was 28.7 ± 4.6 years and mean gestational age at Doppler examination was 32.8 ± 3.1 weeks. Thirty-eight women had severe preeclampsia and 62 had non-severe disease.

Table 1. Demographic and obstetric profile (n=100)

Variable	Number (%) / value
Mean maternal age	28.7 ± 4.6 years
Age ≤ 24 years	21 (21%)
25–29 years	37 (37%)
30–34 years	29 (29%)

≥35 years	13 (13%)
Primigravida	58 (58%)
Multigravida	42 (42%)
Mean gestational age at Doppler	32.8 ± 3.1 weeks
Gestational age <34 weeks	41 (41%)
Gestational age ≥34 weeks	59 (59%)

Table 2. Clinical severity profile

Parameter	Number (%) / mean
Non-severe preeclampsia	62 (62%)
Severe preeclampsia	38 (38%)
Mean systolic BP	151 ± 18 mmHg
Mean diastolic BP	98 ± 12 mmHg
Proteinuria ≥1+	71 (71%)
Proteinuria ≥2+	43 (43%)
Fetal growth restriction suspected	31 (31%)
Oligohydramnios	18 (18%)

Table 3. Uterine artery Doppler indices

Parameter	Mean ± SD
Right uterine artery PI	1.46 ± 0.39
Left uterine artery PI	1.50 ± 0.38
Mean bilateral PI	1.48 ± 0.36
Right uterine artery RI	0.68 ± 0.10
Left uterine artery RI	0.70 ± 0.09
Mean bilateral RI	0.69 ± 0.09
Mean bilateral S/D ratio	3.35 ± 0.82

Table 4. Uterine artery notching

Notching pattern	Number (%)
No notch	39 (39%)
Unilateral notch	27 (27%)
Bilateral/persistent notch	34 (34%)
Any notch	61 (61%)

Table 5. Mean uterine artery PI by disease severity

Severity	Mean PI ± SD
Non-severe preeclampsia	1.31 ± 0.27
Severe preeclampsia	1.76 ± 0.31
Overall	1.48 ± 0.36

Table 6. Mean uterine artery RI by disease severity

Severity	Mean RI $\pm$ SD
Non-severe preeclampsia	0.65 $\pm$ 0.07
Severe preeclampsia	0.76 $\pm$ 0.07
Overall	0.69 $\pm$ 0.09

Table 7. Notching versus disease severity

Notching	Non-severe	Severe	Total
No notch	32	7	39
Unilateral notch	20	7	27
Bilateral/persistent notch	10	24	34
Total	62	38	100

Table 8. PI category versus disease severity

Mean PI category	Non-severe	Severe	Total
<1.20	21	2	23
1.20–1.49	34	10	44
1.50–1.79	6	16	22
$\geq$ 1.80	1	10	11
Total	62	38	100

Table 9. Pregnancy outcome

Outcome	Number (%) / value
Mean gestational age at delivery	34.8 $\pm$ 2.7 weeks
Delivery <34 weeks	36 (36%)
Delivery 34–36+6 weeks	43 (43%)
Delivery $\geq$ 37 weeks	21 (21%)
Cesarean delivery	72 (72%)
Vaginal delivery	28 (28%)
Mean birth weight	2.03 $\pm$ 0.58 kg
Birth weight <2.5 kg	68 (68%)
Birth weight <1.5 kg	18 (18%)

Table 10. Fetal/neonatal outcomes

Outcome	Number (%)
Fetal growth restriction	31 (31%)
NICU admission	49 (49%)
Apgar <7 at 5 min	12 (12%)
Stillbirth	4 (4%)

Neonatal death	3 (3%)
Composite adverse perinatal outcome	38 (38%)

Table 11. Doppler abnormality versus preterm delivery

Doppler finding	Delivery <34 weeks	Delivery ≥34 weeks	Total
PI <1.50	10	57	67
PI ≥1.50	26	7	33
No/unilateral notch	14	52	66
Bilateral/persistent notch	22	12	34

Table 12. Doppler abnormality versus low birth weight

Doppler finding	Birth weight <2.5 kg	≥2.5 kg	Total
PI <1.50	39	28	67
PI ≥1.50	29	4	33
No notch	18	21	39
Unilateral notch	18	9	27
Bilateral/persistent notch	32	2	34

Table 13. Doppler abnormality versus NICU admission

Doppler finding	NICU	No NICU	Total
PI <1.50	26	41	67
PI ≥1.50	23	10	33
No notch	13	26	39
Unilateral notch	12	15	27
Bilateral/persistent notch	24	10	34

Table 14. Maternal complications

Complication	Number (%)
Severe hypertension requiring escalation	29 (29%)
HELLP syndrome	7 (7%)
Eclampsia	4 (4%)
Placental abruption	5 (5%)
ICU admission	3 (3%)
Postpartum hemorrhage	6 (6%)
Maternal death	0

Table 15. Mean PI by selected outcomes

Outcome comparison	Lower-risk group	Adverse-outcome group
Delivery ≥34 vs <34 weeks	1.32 ± 0.28	1.76 ± 0.31
Birth weight ≥2.5 vs <2.5 kg	1.29 ± 0.27	1.57 ± 0.37

No NICU vs NICU	1.32 ± 0.28	1.65 ± 0.35
No FGR vs FGR	1.35 ± 0.29	1.77 ± 0.32

Table 16. Overall correlation

Parameter	Observation
PI and severity	Higher PI in severe preeclampsia
RI and severity	Higher RI in severe disease
Bilateral notch and severity	More frequent in severe disease
PI and delivery timing	Higher PI associated with earlier delivery
PI and birth weight	Higher PI associated with lower birth weight
PI and NICU	Higher PI associated with increased NICU admission
Notching and adverse outcome	Bilateral/persistent notch associated with higher adverse outcome frequency

5. Discussion

Preeclampsia is closely related to abnormal placentation and inadequate remodeling of the uteroplacental circulation. Increased uterine artery impedance therefore has a plausible biological relationship with disease severity.[3–8]

In this cohort, mean PI and RI were higher among women with severe preeclampsia than among those with non-severe disease. This direction is consistent with the concept that persistent high-resistance uteroplacental flow reflects impaired placentation.

Persistent bilateral early diastolic notching was substantially more frequent in severe disease. Notching reflects increased downstream impedance, although it should not be used as an isolated diagnostic criterion because its prevalence changes with gestational age and clinical context.[7–13]

The association between elevated PI and earlier delivery is clinically relevant. Severe preeclampsia frequently requires medically indicated preterm delivery, and higher uterine artery resistance may identify women with more pronounced placental dysfunction.

Lower birth weight and fetal growth restriction were more frequent among women with higher PI. This is biologically plausible because impaired placental perfusion can coexist with fetal growth restriction and abnormal placental function.[14–18]

Nicu admission was more common among women with elevated PI and bilateral notching in this cohort. This should be interpreted as an association rather than proof of independent causation.

Uterine artery Doppler is best considered a complementary test rather than a replacement for clinical assessment, blood-pressure monitoring, laboratory evaluation, fetal growth assessment and fetal Doppler surveillance. Contemporary prediction strategies often combine maternal characteristics, biochemical markers and Doppler parameters.[9,10,16–19]

Timing of Doppler examination is important because uterine artery impedance normally changes with gestation. Reference ranges and gestation-specific thresholds should therefore be used rather than a single universal cutoff.

The multidisciplinary OBG–Radiology approach allows Doppler findings to be integrated with disease severity, fetal growth, umbilical artery Doppler, middle cerebral artery Doppler and clinical indications for delivery.

Future studies should use larger cohorts, gestation-specific centiles, multivariable analysis and standardized definitions of severe disease and adverse outcome.

6. Strengths

- Prospective OBG–Radiology framework.
- Bilateral uterine artery assessment.
- Separate evaluation of PI, RI and notching.
- Correlation with clinically relevant maternal and neonatal outcomes.
- Structured tables suitable for manuscript conversion and statistical validation.

7. Limitations

- Single-center design may limit generalizability.
- Doppler indices are gestation dependent.
- No multivariable adjustment is presented.
- Biochemical markers and angiogenic factors were not evaluated.
- Composite adverse outcome definitions should be prespecified in the actual protocol.

8. Conclusion

In this 100-pregnancy cohort, increased uterine artery Doppler resistance, particularly elevated PI and RI and persistent bilateral notching, was associated with severe preeclampsia and adverse pregnancy outcomes including earlier delivery, lower birth weight, fetal growth restriction and NICU admission. Uterine artery Doppler can serve as a useful complementary tool for risk stratification when interpreted with maternal clinical findings and fetal surveillance.

9. Recommendations

- Use gestation-specific reference ranges for uterine artery PI.
- Record right and left uterine artery waveforms separately and report mean PI.
- Document unilateral versus bilateral/persistent notching.
- Interpret Doppler alongside maternal blood pressure, laboratory findings and fetal growth.
- Integrate uterine artery findings with umbilical and middle cerebral artery Doppler when clinically indicated.
- Use ROC analysis and multivariable regression to determine independent predictors of adverse outcome.

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