

Role of Second Trimester Uterine Artery Doppler Imaging in Prediction of Adverse Pregnancy Outcomes in Hypertensive Pregnancies

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Abstract: ***Background:** Abnormal placentation in hypertensive pregnancy produces high-resistance uteroplacental circulation and contributes to maternal and perinatal complications. Second-trimester uterine artery Doppler provides a non-invasive assessment of this vascular resistance. **Objective:** To evaluate the ability of uterine artery Doppler performed at 18-24 weeks to predict adverse pregnancy outcomes among hypertensive pregnant women. **Methods:** This hospital-based prospective observational study included 150 women with singleton hypertensive pregnancies at PBM Hospital, Bikaner. Bilateral uterine artery Doppler was performed transabdominally. Elevated mean pulsatility index (PI), resistance index (RI), or persistent early-diastolic notching was considered abnormal. Women were classified as normal Doppler (Group A, n=77) or abnormal Doppler (Group B, n=73) and followed until delivery. **Results:** Abnormal Doppler was associated with severe pre-eclampsia (21.92% vs 6.49%; p=0.013), eclampsia (9.59% vs 1.30%; p=0.030), fetal growth restriction (39.73% vs 7.79%; p<0.001), oligohydramnios (32.88% vs 11.69%; p=0.002), cesarean delivery (53.42% vs 32.47%; p=0.010), preterm delivery (46.58% vs 10.39%; p<0.001), 5-minute APGAR <7 (34.25% vs 10.39%; p=0.001), NICU admission (36.99% vs 14.29%; p=0.003), and perinatal mortality (6.85% vs 0%; p=0.025). For fetal growth restriction, sensitivity was 82.86% and negative predictive value was 92.21%. **Conclusion:** Abnormal second-trimester uterine artery Doppler identifies hypertensive pregnancies at increased risk of major maternal and perinatal complications. Its consistently high negative predictive value makes a normal study particularly reassuring; abnormal results should prompt intensified surveillance rather than be used as a stand-alone diagnostic test.*

Keywords: hypertensive disorders of pregnancy; uterine artery Doppler; pulsatility index; resistance index; pre-eclampsia; fetal growth restriction; preterm birth

1. Introduction

Successful placentation depends on trophoblastic transformation of the maternal spiral arteries from narrow, high-resistance vessels into dilated, low-resistance channels. When this remodelling is incomplete, uteroplacental perfusion remains impaired and promotes placental hypoxia, oxidative stress, angiogenic imbalance and maternal endothelial dysfunction. This pathway is central to hypertensive disorders of pregnancy and placental complications such as fetal growth restriction (FGR), oligohydramnios, placental abruption and medically indicated preterm birth [1-4].

Hypertensive disorders remain major causes of maternal and perinatal morbidity and mortality. Their clinical course is heterogeneous: some women remain stable, whereas others rapidly develop severe pre-eclampsia, eclampsia, placental insufficiency or fetal compromise. Risk stratification before overt deterioration is therefore important for determining the

intensity of maternal monitoring, serial fetal growth assessment, referral and timing of delivery [5,6].

Uterine artery Doppler velocimetry offers a non-invasive functional assessment of downstream placental resistance. With normal placentation, the pulsatility index (PI) and resistance index (RI) fall and the early-diastolic notch disappears. Persistence of high PI, high RI or notching in the second trimester indicates increased impedance and has been associated with pre-eclampsia and FGR [7-9]. Meta-analytic evidence suggests that performance is stronger for severe, early or placental-mediated disease than for all adverse outcomes combined, and that a normal test often has greater value for ruling out complications than an abnormal test has for confirming them [10].

Evidence from hypertensive cohorts in Western Rajasthan remains limited. This study therefore evaluated second-trimester uterine artery Doppler findings in hypertensive pregnancies and correlated them with clinically important maternal and perinatal outcomes.

2. Aim and Objectives

The aim was to determine the role of second-trimester uterine artery Doppler imaging in predicting adverse outcomes in hypertensive pregnancies. Objectives were to assess PI, RI and early-diastolic notching; determine their associations with severe pre-eclampsia, eclampsia and placental complications; examine FGR, oligohydramnios, preterm birth, low APGAR score, NICU admission and perinatal mortality; and evaluate Doppler as a tool for early risk stratification.

3. Materials and Methods

A hospital-based prospective observational study was conducted for one year in the Department of Obstetrics and Gynaecology, PBM Hospital, Bikaner. Pregnant women aged >18 years with singleton pregnancies, gestational age 18-24 weeks, and hypertension diagnosed according to national guidelines were enrolled by convenience sampling after written informed consent. Women declining consent, those with multiple gestation, major fetal congenital anomaly or normotensive were excluded. Based on an expected 11% prevalence of abnormal uterine artery Doppler, 95% confidence level and 5% allowable error, the calculated sample was 139; 150 women were enrolled to allow for incomplete observations. Clinical history and examination findings were recorded in a predesigned proforma. Complete blood count, liver and kidney function tests, urine microscopy and protein assessment were performed. After 10 minutes of rest in a semi-recumbent position, transabdominal Doppler was undertaken using a 2-5 MHz probe. Each uterine artery was identified where it crossed the external iliac artery, and the sample volume was placed approximately 1 cm distal to the crossover; the contralateral artery was assessed similarly. PI and RI were recorded and the waveform was examined for an early-diastolic notch. Impaired flow was defined by persistent unilateral or bilateral notching, mean PI >1.6, or RI $\geq$ 0.59. Group A comprised women with normal Doppler (n=77) and Group B those with abnormal Doppler (n=73).

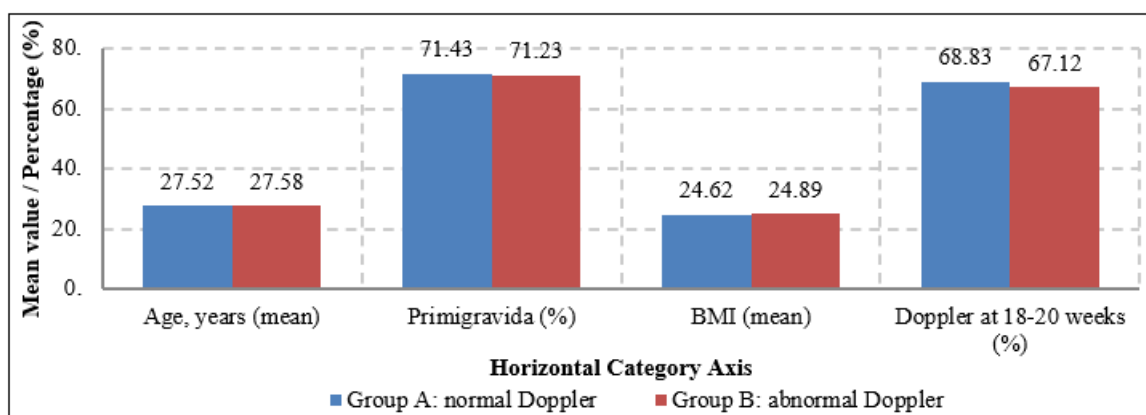
Participants were followed up till delivery with serial blood pressure, weight, fundal height, urinary protein and fetal-wellbeing assessments. Outcomes included severe pre-eclampsia, eclampsia, placental insufficiency, FGR, oligohydramnios, abruption, mode and gestational age at delivery, 5-minute APGAR score, NICU admission and perinatal mortality. Categorical variables were summarized as number and percentage and quantitative variables as mean $\pm$ SD. Appropriate tests compared groups; $p < 0.05$ was significant. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated from 2x2 tables. Institutional ethics approval was obtained; confidentiality and standard clinical management were maintained.

4. Results

Among 150 hypertensive pregnancies, 77 (51.33%) had normal and 73 (48.67%) had abnormal uterine artery Doppler. Baseline age, gravidity, BMI and gestational age at scanning were comparable. Mean PI (1.42 $\pm$ 0.34 vs 0.96 $\pm$ 0.21) and RI (0.68 $\pm$ 0.12 vs 0.51 $\pm$ 0.09) were significantly higher in Group B (both $p < 0.001$). The commonest abnormal pattern was high PI with a notch (12.0% of the cohort), followed by high RI with a notch (10.0%).

Table 1: Baseline characteristics of the study groups

Characteristic	Group A: normal Doppler (n=77)	Group B: abnormal Doppler (n=73)	p value
Age, years (mean $\pm$ SD)	27.52 $\pm$ 5.38	27.58 $\pm$ 5.04	0.948
Primigravida, n (%)	55 (71.43)	52 (71.23)	1
BMI, kg/m ² (mean $\pm$ SD)	24.62 $\pm$ 3.51	24.89 $\pm$ 3.68	0.61
Doppler at 18-20 weeks, n (%)	53 (68.83)	49 (67.12)	0.976

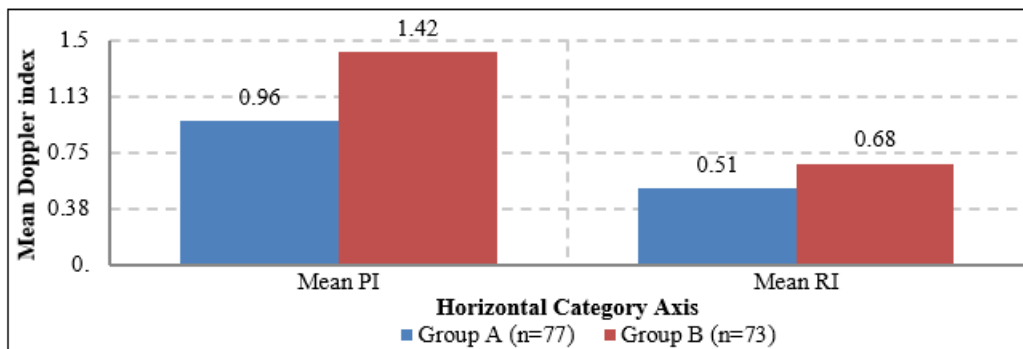


Graph 1: Baseline characteristics of the study

Table 2: Uterine artery Doppler findings

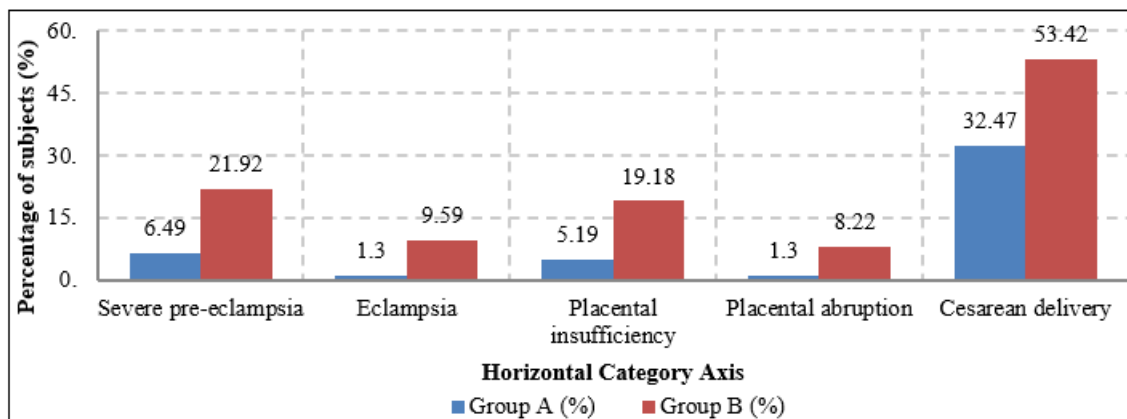
Parameter	Group A (n=77)	Group B (n=73)	p value
Mean PI	0.96 $\pm$ 0.21	1.42 $\pm$ 0.34	<0.001
Mean RI	0.51 $\pm$ 0.09	0.68 $\pm$ 0.12	<0.001
Total abnormal Doppler	-	73 (100%)	-
Most frequent pattern	-	High PI + notch: 18 (24.66% of Group B)	-

Maternal complications were more frequent after an abnormal study. Severe pre-eclampsia increased from 6.49% to 21.92% and eclampsia from 1.30% to 9.59%. Cesarean delivery was also more frequent. Abruption showed a clinically higher rate (8.22% vs 1.30%) but did not reach conventional statistical significance ($p = 0.058$).

**Graph 2:** Uterine artery Doppler findings**Table 3:** Maternal and obstetric outcomes according to Doppler findings

Outcome	Group A n (%)	Group B n (%)	p value
Severe pre-eclampsia	5 (6.49)	16 (21.92)	0.013
Eclampsia	1 (1.30)	7 (9.59)	0.03
Placental insufficiency	4 (5.19)	14 (19.18)	0.017
Placental abruption	1 (1.30)	6 (8.22)	0.058
Cesarean delivery	25 (32.47)	39 (53.42)	0.01

Adverse fetal and neonatal outcomes were consistently more common in Group B. FGR was approximately five times as frequent, and nearly half of Group B delivered before 37 weeks. Low 5-minute APGAR score, NICU admission and perinatal mortality were also significantly associated with abnormal Doppler.

**Graph 3:** Maternal and obstetric outcomes according to Doppler findings**Table 4:** Fetal and perinatal outcomes according to Doppler findings

Outcome	Group A n (%)	Group B n (%)	p value
Fetal growth restriction	6 (7.79)	29 (39.73)	<0.001
Oligohydramnios	9 (11.69)	24 (32.88)	0.002
Preterm delivery <37 weeks	8 (10.39)	34 (46.58)	<0.001
5-minute APGAR <7	8 (10.39)	25 (34.25)	0.001
NICU admission	11 (14.29)	27 (36.99)	0.003
Perinatal mortality	0 (0.00)	5 (6.85)	0.025

Abnormal Doppler demonstrated its best balanced performance for FGR and preterm delivery. NPV was high across severe outcomes, including 93.51% for severe pre-eclampsia, 92.21% for FGR, 89.61% for preterm delivery and 100% for perinatal mortality. PPV was modest for several outcomes, indicating that an abnormal result is a risk marker rather than a definitive diagnosis.

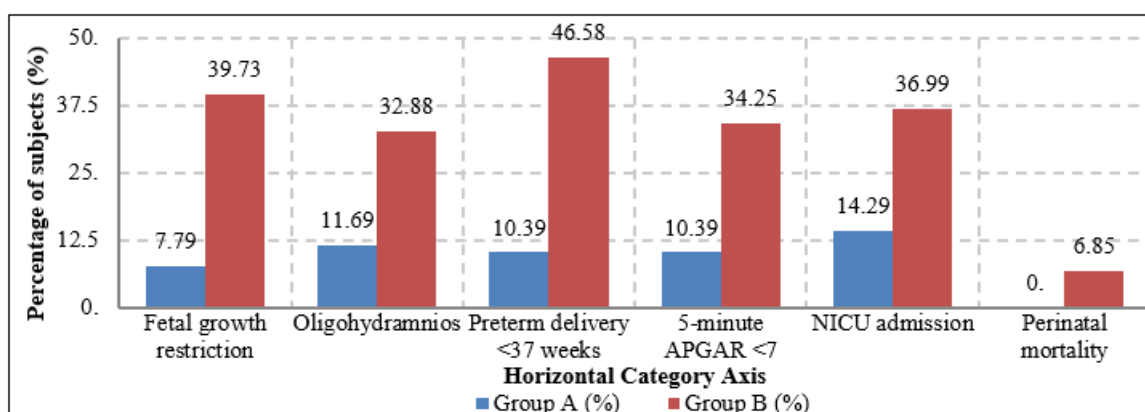
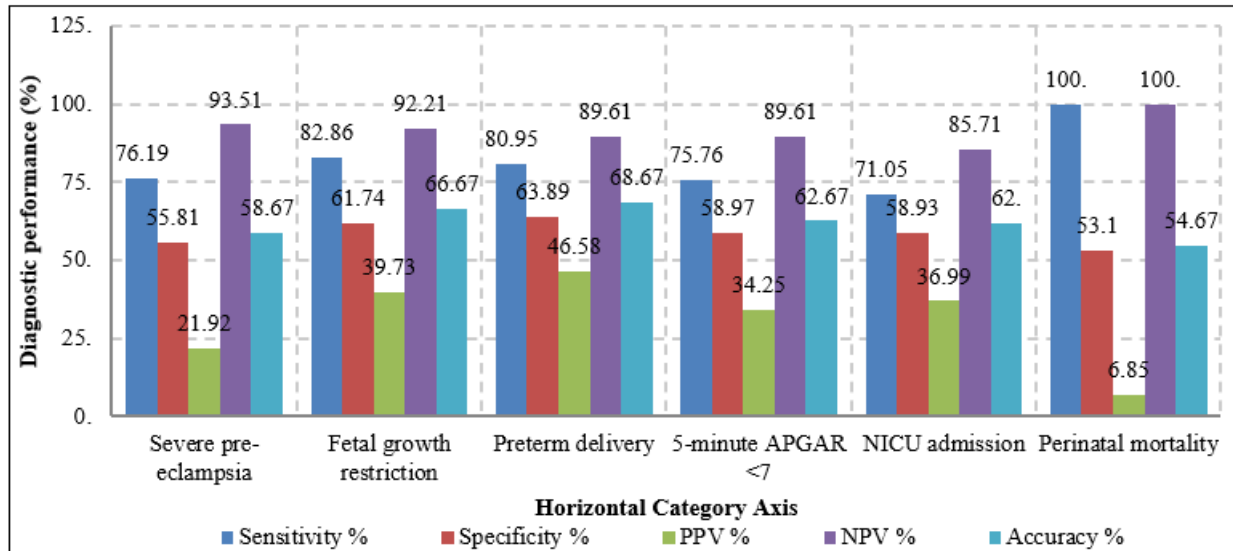
**Graph 4:** Fetal and perinatal outcomes according to Doppler findings

Table 5: Diagnostic performance of abnormal uterine artery Doppler

Outcome	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %
Severe pre-eclampsia	76.19	55.81	21.92	93.51	58.67
Fetal growth restriction	82.86	61.74	39.73	92.21	66.67
Preterm delivery	80.95	63.89	46.58	89.61	68.67
5-minute APGAR <7	75.76	58.97	34.25	89.61	62.67
NICU admission	71.05	58.93	36.99	85.71	62
Perinatal mortality	100	53.1	6.85	100	54.67

**Graph 5:** Diagnostic performance of abnormal uterine artery Doppler

5. Discussion

This prospective study demonstrates a clear relationship between abnormal second-trimester uterine artery Doppler and adverse outcomes in hypertensive pregnancy. Because age, gravidity, BMI and scan timing were comparable, the observed differences are less likely to reflect imbalance in these measured baseline characteristics. The 48.67% prevalence of abnormal Doppler was higher than the 21.2% reported by Verma and Gupta [11], plausibly because the present cohort included only hypertensive women, who have a greater burden of impaired placentation.

Elevated PI and RI were accompanied by substantially higher rates of severe pre-eclampsia and eclampsia. These findings align with studies in high-risk pregnancy showing that persistent resistance and notching predict subsequent hypertensive severity [12-14]. The association was even stronger for placental-mediated fetal outcomes: FGR occurred in 39.73% versus 7.79%, oligohydramnios in 32.88% versus 11.69%, and preterm birth in 46.58% versus 10.39%. These results are biologically coherent, because deficient spiral-artery remodelling reduces placental perfusion and limits fetal growth and reserve. Similar associations with FGR, low birth weight and preterm birth have been described in Indian cohorts [15,16].

The abnormal group also experienced more cesarean delivery, low 5-minute APGAR scores, NICU admissions and perinatal deaths. These outcomes probably reflect the combined effects of hypertensive severity, placental insufficiency, FGR and prematurity rather than a direct effect of the Doppler waveform itself. Placental abruption was more frequent but

narrowly missed significance, suggesting inadequate power for this relatively uncommon event.

The most clinically useful feature was the high NPV of a normal Doppler, especially for severe pre-eclampsia, eclampsia, FGR and perinatal mortality. Conversely, low-to-moderate PPV means that abnormal Doppler should not trigger intervention in isolation. It should refine, not replace, assessment based on blood pressure, proteinuria, laboratory findings and fetal surveillance. Limitations include convenience sampling, a single-centre hospital-based cohort, lack of multivariable adjustment, operator-dependent measurement, and absence of external validation. Larger multi centre studies using gestation-specific PI percentiles and combined clinical/biochemical models are warranted.

6. Conclusion

Second-trimester uterine artery Doppler imaging is a useful non-invasive risk-stratification tool in hypertensive pregnancies. Elevated PI or RI and persistent early-diastolic notching identified women with significantly increased risks of severe pre-eclampsia, eclampsia, placental insufficiency, FGR, oligohydramnios, cesarean delivery, preterm birth, low 5-minute APGAR score, NICU admission and perinatal mortality. The strongest predictive performance was observed for FGR and preterm delivery, while a normal Doppler provided substantial reassurance because of its high negative predictive value.

Clinical use should therefore focus on guiding surveillance rather than making a stand-alone diagnosis. Women with abnormal findings merit closer blood-pressure and laboratory monitoring, serial growth and amniotic-fluid assessment,

timely referral, and individualised delivery planning. Normal findings do not eliminate risk in an already hypertensive pregnancy and routine clinical monitoring must continue. Integration of uterine artery Doppler with maternal characteristics, angiogenic biomarkers and fetal assessment may improve prediction further. Multi centre prospective validation is needed before fixed thresholds or management algorithms are adopted across populations.

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