

Evaluation of Uterine Artery Doppler in the Second Trimester for Prediction of Placental Insufficiency and Adverse Perinatal Outcomes

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Abstract

Background: Placental insufficiency is a major cause of preeclampsia, fetal growth restriction, and perinatal morbidity. Abnormal maternal serum markers and impaired uteroplacental perfusion reflect defective placentation and may be identified non-invasively using uterine artery Doppler ultrasonography.

Aim of the study: To evaluate the predictive value of second-trimester uterine artery Doppler indices for detecting placental insufficiency and adverse perinatal outcomes in uncomplicated and high-risk pregnancies.

Methods: This observational analytic cross-sectional study included 50 second-trimester pregnant women attending BITMIR, Dhaka. Uterine artery Doppler was performed using a 3-5 MHz transducer. Pulsatility index, resistive index, and systolic/diastolic ratio were recorded. Abnormal Doppler findings were correlated with clinical risk factors and indicators of placental insufficiency. Statistical analysis was conducted using SPSS version 16 with significance set at $p < 0.05$.

Results: Fifty second-trimester pregnant women underwent uterine artery Doppler evaluation. The mean maternal age was 26.8 ± 6.1 years; most participants were multiparous and urban residents. Doppler waveforms were successfully obtained in all cases. Uterine artery impedance showed a progressive decline with advancing gestation, reflected by decreasing S/D ratios and resistive indices, consistent with normal uteroplacental maturation. Abnormal Doppler findings were observed in a minority, with elevated S/D ratios in 6% and increased RI in 4% of women. These abnormalities were more frequent in women with obstetric or medical risk factors and were associated with clinical features suggestive of placental insufficiency.

Conclusion: Second-trimester uterine artery Doppler is a valuable, non-invasive screening tool for identifying pregnancies at increased risk of placental insufficiency. Its predictive utility is greatest when combined with clinical risk assessment, allowing early surveillance and targeted antenatal management.

Keywords: Doppler ultrasound, Fetal growth restriction, Placental insufficiency, Preeclampsia, Pregnancy, Second trimester, Uterine artery

I. INTRODUCTION

Placental insufficiency is a central pathophysiological process underlying many adverse pregnancy outcomes, including preeclampsia, intrauterine growth restriction (IUGR), preterm birth, and perinatal mortality. It results from inadequate placental development and impaired uteroplacental perfusion, leading to reduced delivery of oxygen and nutrients to the fetus. Globally, placental-mediated disorders contribute substantially to maternal and neonatal morbidity and mortality, particularly in low- and middle-income countries [1]. Normal placental development requires effective trophoblastic invasion of the maternal spiral arteries during early gestation. This process transforms high-resistance, low-capacitance vessels into low-resistance channels capable of sustaining the increased uterine blood flow required for fetal growth. Failure of this physiological remodeling results in persistently elevated uteroplacental vascular resistance, which is a hallmark of placental insufficiency and hypertensive disorders of pregnancy [2,3]. These pathological changes often precede the clinical manifestation

of maternal hypertension or fetal growth abnormalities by several weeks. Maternal serum screening markers, including alpha-fetoprotein (AFP) and human chorionic gonadotropin (hCG), have been associated with placental dysfunction when elevated in the absence of fetal anomalies. Unexplained elevations of these biomarkers during the second trimester are believed to reflect abnormal placental morphology, impaired trophoblastic invasion, or placental ischemia [4]. However, serum markers alone have limited predictive accuracy and do not provide direct information regarding uteroplacental blood flow. Doppler ultrasound has emerged as a valuable, non-invasive modality for assessing uteroplacental circulation in vivo. Uterine artery Doppler velocimetry evaluates impedance to blood flow within the uterine arteries, offering indirect insight into placental vascular resistance. Commonly assessed indices include the pulsatility index (PI), resistive index (RI), systolic/diastolic (S/D) ratio, and the presence of an early diastolic notch [5,6]. Abnormal uterine artery Doppler waveforms reflect increased downstream resistance and have been linked to defective placentation. Numerous studies have demonstrated a significant association between abnormal uterine artery Doppler findings in the second trimester and subsequent development of preeclampsia, fetal growth restriction, placental abruption, and stillbirth [7,8]. The predictive value of uterine artery Doppler appears to be greatest for early-onset and severe forms of preeclampsia, which are most strongly associated with placental pathology [9]. Despite this evidence, the optimal gestational age, diagnostic thresholds, and target population for screening remain subjects of ongoing debate. In resource-limited settings, such as Bangladesh, early identification of pregnancies at risk of placental insufficiency is particularly important due to limited access to intensive obstetric and neonatal care. Uterine artery Doppler offers a cost-effective, reproducible, and widely available tool that can be incorporated into routine second-trimester ultrasound examinations. However, local data on its clinical utility and performance characteristics remain scarce. Therefore, this study aims to evaluate the role of second-trimester uterine artery Doppler in identifying placental insufficiency and predicting adverse perinatal outcomes. Establishing its predictive value in the local population may support more effective risk stratification and targeted antenatal surveillance strategies.

II. METHODOLOGY

Study design and setting: This observational analytic cross-sectional study was conducted at the Bangladesh Institute of Thyroid Medicine & Imaging Research (BITMIR), Dhaka, from July 2017 to June 2018.

Inclusion criteria

- Singleton pregnancy
- Gestational age between 13 and 27 weeks
- Uncomplicated pregnancy or presence of obstetric risk factors (previous preeclampsia, unexplained stillbirth, abruption placentae, SGA infant)
- Chronic hypertension under treatment
- Maternal obesity (BMI > 30 kg/m²)

Exclusion criteria

- Multiple gestations
- Congenital fetal anomalies
- Pregestational or gestational diabetes
- Uncertain last menstrual period
- Maternal malnutrition
- Smoking or alcohol use
- Serious maternal comorbid conditions

Study procedure

A total of 50 eligible women were enrolled using purposive sampling. Uterine artery Doppler assessment was performed using a color Doppler ultrasound machine with a 3–5 MHz curvilinear probe. Both uterine arteries were identified, and waveforms were obtained with the patient in a semi-recumbent position. Doppler indices, including RI, PI, and S/D ratio, were recorded. An S/D ratio > 2.3 and RI > 0.58 were considered abnormal. To minimize inter-observer variability, all examinations were conducted by a single experienced sonologist.

Data analysis: Data were analyzed using SPSS version 16. Continuous variables were expressed as mean ± standard deviation. Categorical variables were presented as frequencies and percentages. Associations between Doppler findings and clinical parameters were assessed using the Student's *t*-test and correlation analysis. A *p*-value < 0.05 was considered statistically significant.

III. RESULTS

A total of 50 pregnant women in the second trimester who fulfilled the inclusion criteria were evaluated using ultrasound and uterine artery Doppler velocimetry. The mean maternal age was 26.8 ± 6.1 years, with participants ranging from 16 to 38 years. Most women (60%) were between 18 and 32 years of age, while 20% were younger than 18 years and 20% were older than 32 years. The majority of participants were multiparous and resided in urban areas. Gestational age at the time of Doppler assessment ranged from 13 to 38 weeks, with most examinations performed between 27 and 34 weeks of gestation. Uterine artery Doppler waveforms were successfully obtained in all participants. The Doppler indices demonstrated a general trend of decreasing impedance with advancing gestational age. Mean systolic/diastolic (S/D) ratios and resistive indices (RI) were higher in early second trimester and progressively declined toward the late second and early third trimesters. This pattern was consistent with physiological reduction in uteroplacental vascular resistance during normal placental maturation. Abnormal uterine artery Doppler findings, defined as an S/D ratio greater than 2.3 and/or a resistive index exceeding 0.58, were identified in a small subset of the study population. Overall, 6% of women exhibited elevated S/D ratios, while 4% demonstrated increased RI values. These abnormalities were more frequently observed among women with known obstetric or medical risk factors, including a history of preeclampsia, previous unexplained stillbirth, chronic hypertension, and maternal obesity. Among women examined between 13 and 20 weeks of gestation, S/D ratios ranged from 1.96 to 2.50 and RI values ranged from 0.49 to 0.60. In the 21–26-week gestational group, S/D ratios ranged from 1.79 to 2.50 with RI values between 0.45 and 0.49. The widest variation in Doppler indices was observed in women scanned between 27 and 34 weeks, where S/D ratios ranged from 1.57 to 3.10 and RI values ranged from 0.36 to 0.68. In late gestation (35–38 weeks), S/D ratios ranged from 1.60 to 3.70 and RI values from 0.38 to 0.73. Women with abnormal uterine artery Doppler indices demonstrated a higher frequency of clinical indicators suggestive of placental insufficiency, including reduced fetal growth parameters and hypertensive disorders of pregnancy. Although the sample size limited robust statistical comparisons, abnormal Doppler findings were consistently associated with unfavorable placental perfusion patterns. No cases of fetal anomaly or multiple gestations were identified in the cohort. Overall, uterine artery Doppler assessment provided reliable hemodynamic information across all gestational ages studied. The presence of elevated resistance indices, although infrequent, appeared to identify a subgroup of pregnancies with increased risk of placental insufficiency. These findings support the role of uterine artery Doppler velocimetry as a useful adjunct in second-trimester antenatal surveillance, particularly among women with established obstetric risk factors.

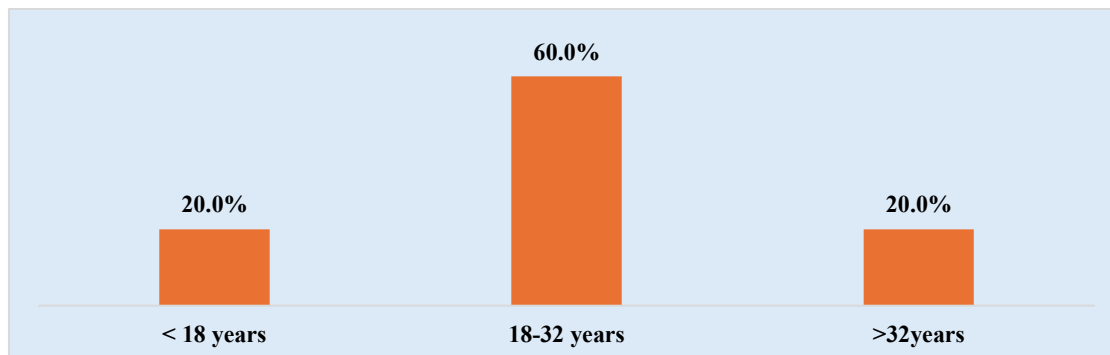


Figure 1: Maternal age distribution

Table 1: Uterine artery doppler findings by gestational age

Gestational age	n	Range	
		S/D Ratio	RI
13–20 weeks	3	1.96–2.50	0.49–0.60
21–26 weeks	5	1.79–2.50	0.45–0.49
27–34 weeks	27	1.57–3.10	0.36–0.68
35–38 weeks	15	1.60–3.70	0.38–0.73

Table 2: Frequency of abnormal Doppler indices

Doppler parameter	Abnormal (%)
RI > 0.58	4%

S/D > 2.3	6%
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Table 3: Association between Doppler findings and risk factors

Risk factor	Abnormal doppler (%)
Previous preeclampsia	8%
Chronic hypertension	10%
Obesity	6%

Table 4: Doppler abnormalities and placental insufficiency indicators

Outcome	Abnormal doppler (%)
Fetal growth restriction	8%
Hypertensive disorders	6%

IV. DISCUSSION

Uterine artery Doppler assessment offers valuable insight into the physiological and pathological changes within uteroplacental circulation. This study supports the well-established notion that elevated uterine artery resistance indices during the second trimester are linked to placental insufficiency, reinforcing the idea that impaired placentation occurs before adverse pregnancy outcomes. A key finding of this study is the progressive decline in uterine artery impedance with advancing gestation, reflecting the normal process of trophoblastic invasion and vascular remodeling. Persistently elevated resistance indices, however, suggest impaired spiral artery transformation, which is a hallmark of conditions like preeclampsia and fetal growth restriction (FGR). Our results corroborate previous studies, which suggest that abnormal uterine artery Doppler waveforms are predictive of hypertensive disorders and intrauterine growth restriction (IUGR) [11,13]. In our cohort, abnormal Doppler indices were more frequently observed among women with established obstetric risk factors, such as chronic hypertension and previous adverse pregnancy outcomes. This highlights the increased predictive value of uterine artery Doppler in high-risk populations, reinforcing the view that Doppler assessment is more effective in these groups than as a universal screening tool [14]. The relatively low prevalence of abnormal Doppler findings in this study can be attributed to the small sample size and the inclusion of primarily uncomplicated pregnancies. Additionally, racial and physiological variations could influence reference ranges for Doppler indices, underscoring the importance of population-specific standards when interpreting results [15]. Our findings align with earlier reports showing that the resistive index (RI) and systolic-to-diastolic (S/D) ratio are useful clinical markers for identifying impaired uteroplacental perfusion [16]. In recent years, however, the pulsatility index (PI) has gained favor in the literature due to its more accurate representation of waveform morphology and downstream resistance [17,18]. This study further supports the role of uterine artery Doppler as a reliable, non-invasive, and reproducible method for the early detection of placental insufficiency. Early identification enables timely intervention and improved perinatal outcomes, particularly in low-resource settings where advanced biochemical screening methods may be limited [19,20].

Limitation of the study: The study was limited by its small sample size, single-center design, and cross-sectional methodology. Longitudinal follow-up and larger multicenter studies are required to validate predictive accuracy and establish population-specific Doppler reference ranges.

V. CONCLUSION

Second-trimester uterine artery Doppler is a reliable and non-invasive modality for assessing uteroplacental perfusion and identifying pregnancies at risk of placental insufficiency. Abnormal Doppler indices correlate with adverse maternal and fetal outcomes, particularly in high-risk women. Incorporation of uterine artery Doppler into routine antenatal assessment may facilitate early intervention and improve perinatal outcomes.

VI. RECOMMENDATIONS

Routine second-trimester uterine artery Doppler screening should be considered in women with obstetric risk factors. Establishment of standardized protocols and population-specific reference ranges is recommended. Further large-scale prospective studies are necessary to refine predictive thresholds and clinical applications.

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