



The Role of Uterine Artery Doppler in the Prediction of Pre-eclampsia

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ABSTRACT

Background: The Doppler technique is a noninvasive method for evaluating the blood flow in the fetus and placenta. It is a potential screening tool for identifying pregnancies at higher risk of developing preeclampsia. This study aimed to identify any abnormalities in uterine artery Doppler among pregnant females between 19 and 26 weeks of gestation that may indicate potential complications like preeclampsia.

Methods: The study was conducted at Zagazig University Hospital and El-Galaa Teaching Hospital, involving 150 pregnant women attending the antenatal care clinic. The participants had a gestational age between 19 and 26 weeks and were assessed and monitored using Doppler.

Results: Out of the 150 pregnant patients enrolled in the study, 20 cases (13.3%) developed preeclampsia. Among these cases, 12 (8%) experienced perinatal complications, including Intrauterine fetal death (IUFD), intrauterine growth restriction (IUGR), antepartum hemorrhage, and postpartum hemorrhage. IUFD and IUGR were reported in 4 (2.7%) cases each, antepartum hemorrhage in 3 (2%) cases, and postpartum hemorrhage in 1 case (0.667%). We observed a significant increase in the mean uterine artery Resistance index (RI) and Pulsatility index (PI) in women who developed preeclampsia compared to those who did not ($p < 0.001$).

Conclusions: Uterine artery Doppler is an easy, fast, and non-invasive screening test that may add help in preeclampsia prediction. RI was a significant predictor for Uterine artery Doppler at a cutoff value of >0.58 with AUC 0.951 with 95% Sensitivity and 93.8% Specificity. PI was a significant predictor for Uterine artery Doppler at a cutoff value of >1.1 with AUC.

Keywords: Uterine artery Doppler; pre-eclampsia; prediction

INTRODUCTION

Preeclampsia is a major global cause of maternal and fetal mortality, affecting around 2 to 3 percent of pregnant women and accounting for approximately 10 percent of all patient deaths.[1,2]. Preeclampsia is typically diagnosed after the 20th week of pregnancy when the mother develops hypertension (when the blood pressure is higher than 140/90 mmHg) and has proteinuria (excretion of greater than 0.3 g of protein in 24 hours) [3]. Nonetheless, identifying the pregnancies most susceptible to developing preeclampsia and its associated risks to both the mother and fetus continues to present a difficulty.

In recent years, spectral Doppler monitoring of the uterine artery (UA) has been studied as a screening method for predicting pre-eclampsia before the onset of clinical symptoms. Adekanmi et al. [4] findings suggest that uterine artery Doppler can be used as a predictive tool for severe adverse outcomes in individuals with a high risk of developing pre-eclampsia. Additionally, Chilumula et al. [5] have shown that abnormalities in placental blood flow occur before the clinical symptoms of preeclampsia. Furthermore, the Doppler examination is a secure and non-intrusive technique to evaluate the fetal and placental condition throughout pregnancy [6]. Preeclampsia can be

predicted by a cheap screening procedure involving uterine artery Doppler abnormalities such as notching, an elevated resistance index, and an increased pulsatility index [7].

Our study aimed to identify any abnormal Doppler findings during the 19 to 26 weeks of pregnancy that may suggest an increased risk of developing preeclampsia.

METHODS

The research took place at Zagazig University Hospital and El-Galaa Teaching Hospital over one year, from May 2022 to May 2023. After institutional review board approval of IRB (#8081/28-11-2021), written informed consent was obtained from all participants. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria: A group of 150 pregnant women between 19 and 26 weeks into their pregnancies were selected to participate in the study who had singleton pregnancy (Figure 1).

Exclusion criteria: Those with congenital fetal anomalies, multiple pregnancies, chronic hypertension, renal disease, cardiac disease, and congenital uterine anomalies were excluded from the study.

All participants underwent uterine artery Doppler assessment using the abdominal probe of the Mindray DC70 and the Voluson 730 pro ultrasound equipment. The uterine artery was detected at the junction between the uterus and cervix, near the point where the uterine and external iliac arteries intersect. The ultrasound transducer was pointed at the uterine lateral walls and down into the pelvis for color flow mapping, using a transducer inserted into the patient's abdomen (either the patient's left or right iliac fossa). After turning on the pulsed wave gate, the following parameters were evaluated:

The resistance index (RI) was assessed utilizing the formula $RI = \frac{\text{Peak systolic velocity} - \text{Peak diastolic velocity}}{\text{Peak systolic velocity}}$.

The pulsatility index (PI) was assessed utilizing the formula $PI = \frac{\text{Peak systolic velocity} - \text{End diastolic velocity}}{\text{Mean velocity}}$, and we automatically calculated it.

The patients were monitored until delivery for any occurrence of preeclampsia, which was termed the development of new-onset hypertension (when the blood pressure was higher than 140/90 mmHg) and proteinuria (higher than 0.3 g/24 h) [3]. Cases were

followed up throughout the rest of pregnancy till delivery.

STATISTICAL ANALYSIS

IBM's statistical analysis software, SPSS, version 19.0, was used to process the data. Qualitative data was represented with numerical and percentage-based language. Quantitative information was summarized by means and standard deviations. For quantitative variables, we performed Mann-Whitney U tests for non-parametric data and independent t-tests for parametric data when comparing two groups.

RESULTS

The age of the cases in the study ranged from 21 to 39 years, with a mean age of 28.06 ± 4.35 years. The mean BMI was 27.51 ± 1.46 Kg/m², and the mean parity was 2.13 ± 0.81 (Table 1). The mean uterine artery RI and PI in the women studied were 0.56 ± 0.074 and 1.04 ± 0.14 , respectively (Table 2). Out of the total cases, 20 (13.3%) developed preeclampsia, and 12 (8%) of them experienced complications such as IUFD, IUGR, antepartum and postpartum hemorrhage, with rates of 2.7%, 2.7%, 2%, and 0.667%, respectively (Table 3). The cases were monitored throughout pregnancy for the detection of preeclampsia.

In our study, we observed that the mean uterine artery Resistance Index (RI) and Pulsatility Index (PI) were (0.69 ± 0.05 and 0.54 ± 0.05) and (1.33 ± 0.08 and 0.85 ± 0.08) in the cases who developed preeclampsia and those who did not. We found that preeclamptic women had significantly higher Resistance and Pulsatility indices than their non-preeclamptic counterparts ($p < 0.001$). Table 4 provides a summary of these results.

Furthermore, the Resistance index (RI) showed significant predictive value for Uterine artery Doppler with a cutoff value of >0.58 , achieving an AUC of 0.951 with 95% Sensitivity, 93.8% Specificity, 83.6% NPV and 87.2% PPV. Similarly, the Pulsatility index (PI) demonstrated significant predictive value for Uterine artery Doppler with a cutoff value of >0.1 , achieving an AUC of 0.991 with 95% Sensitivity, 98.5% Specificity, 72.9% NPV, and 81.4% PPV (Table 5 and Figures 2 and S1).

S2: showing normal uterine artery Doppler indices in a case who continued normally till the end of pregnancy.

S3: showing high uterine artery Doppler indices in a case who developed preeclampsia.

Table 1: Distribution of studied cases as per demographic characteristics and obstetric history.

Parameters		Studied cases (n= 150)
Age (years)	Mean± SD	28.06 ± 4.30
BMI (Kg/m ²)	Mean± SD	27.51 ± 1.46
Parity	Mean± SD	2.13 ± 0.81
Gestational age (weeks)	Mean± SD	22.87 ± 1.65

SD= standard deviation, n: number, %: percentage

Table 2: Distribution of studied cases as regards uterine artery Doppler findings.

Parameters		Studied cases (n= 150)
RI	Mean± SD	0.56 ± 0.074
PI	Mean± SD	1.04 ± 0.14

PI: pulsatility index, RI: resistive index SD= standard deviation, n: number, %: percentage

Table 3: Distribution of studied cases as regards maternal outcome

Parameters		Studied cases (n= 150)	
		n	%
Preeclampsia	No	130	86.7%
	Yes	20	13.3%
Complications	No	138	92.0%
	APH	3	2.0%
	IUFD	4	2.7%
	IUGR	4	2.7%
	PPH	1	0.7%

PI: pulsatility index, RI: resistive index SD= standard deviation, n: number, %: percentag

Table 4: Correlation between preeclampsia and Uterine artery Doppler (RI & PI).

		No preeclampsia (No. = 130)	Preeclampsia (No. = 20)	Test value	P-value
RI	Mean± SD	0.54 ± 0.05	0.69 ± 0.05	Z _{MWU} =6.52	<0.001
PI	Mean± SD	0.85 ± 0.08	1.33 ± 0.08	Z _{MWU} =7.1	<0.001

PI: pulsatility index, RI: resistive index $p \leq 0.05$ is considered statistically significant, $p \leq 0.01$ is considered high statistically significant, SD= standard deviation, * Chi- Square test and Mann-Whitney U test

Table 5: ROC curve analysis to predict the diagnostic performance of Uterine artery Doppler.

Variable	Area	P-value	Cutoff	Sensitivity	Specificity	NPV	PPV
RI	0.951	<0.001*	>0.58	95%	93.8%	83.6%	87.2%
PI	0.991	<0.001*	>1.1	95%	98.5%	72.9%	81.4%

PI: pulsatility index, RI: resistive index NPV: Negative predictive value, PPV: Positive predictive value

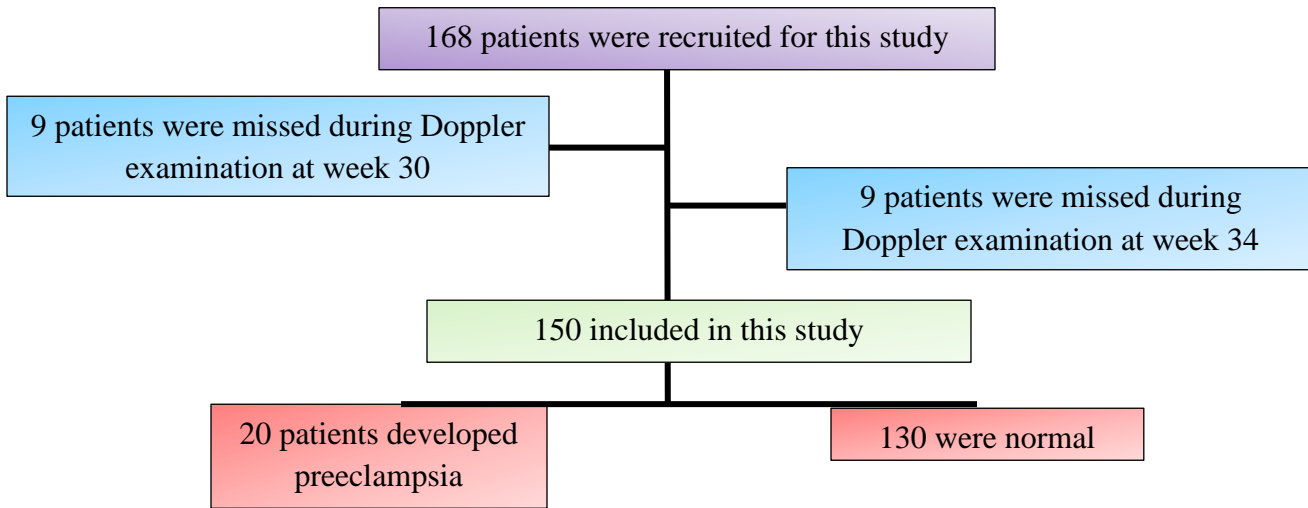


Figure 1: Flowchart of All cases

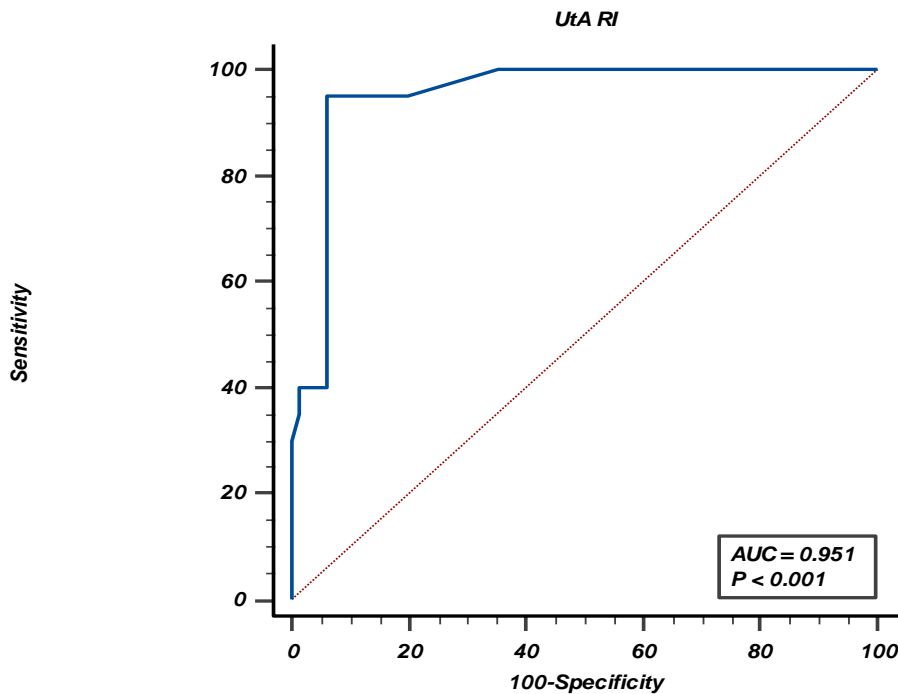


Figure 2: ROC curve of RI in prediction of preeclampsia.

DISCUSSION

Detecting and predicting pre-eclampsia, especially in high-risk pregnant women, is critical because it is the primary cause of maternal death and morbidity. Important for early intervention, which can have positive effects on maternal and fetal health [7].

Although medical research has made significant progress, there is still a lack of a dependable

screening test to predict these negative outcomes. Preeclamptic women have an elevated chance of having cardiovascular problems. In addition, preeclamptic pregnancies are associated with smaller-than-average birth weights and an increased

risk of adult stroke, heart disease, and metabolic syndrome [8].

Accurately identifying or predicting pre-eclampsia, particularly in high-risk mothers, is crucial for providing appropriate care that can significantly enhance outcomes for both the mother and the fetus [8].

During a human pregnancy, it is not possible to directly evaluate trophoblast invasion. Doppler imaging allows for the noninvasive evaluation of uteroplacental circulation via the comparison of systolic and diastolic waveforms [8].

Adekanmi et al. [4] mentioned that the use of UA Doppler in predicting severe adverse outcomes in high-risk patients with pre-eclampsia has shown promising clinical value.

Furthermore, provided evidence that there are signs of impaired placental perfusion before the onset of clinical symptoms of preeclampsia. This study aimed to identify abnormal Doppler findings during the 19-to-26-week period of pregnancy, which may serve as indicators of later complications and aid in predicting the development of pre-eclampsia.

The incidence of preeclampsia in the current study was 13.3%, which was in accordance with the results of Fatima et al. [9] who reported a 16% incidence in women screened between 18-24 weeks of gestation. However, Chyad et al. [10] and Litwinska et al., [11] reported a higher incidence of 30% and 32 % respectively in their study on women at 14-20 weeks of gestation. This difference may be attributed to the smaller sample size, different gestational age groups, or ethnic susceptibility in their study. A significant increase in the Resistance Index (RI) and Pulsatility Index (PI) values was observed in women who developed preeclampsia compared to those who did not ($p < 0.001$). The average RI of the uterine artery was higher in women with preeclampsia (0.69 ± 0.05) compared to those without preeclampsia (0.54 ± 0.05). Similarly, the average PI of the uterine artery was higher in women with preeclampsia (1.33 ± 0.08) compared to those without preeclampsia (0.85 ± 0.08) (cut-off value of >0.58 and >0.1 respectively, AUC 0.951 and 0.991, respectively) with a sensitivity of 95% and 93.8% and specificity of 98.5% and 98.5%, respectively.

In the same line with our results, a Doppler ultrasound of the uterine artery was done at 21 weeks of pregnancy, and Yang et al. [12] evaluated data from 2039 pregnancies, they found that The PI was just as sensitive (83.8%), just as specific (91.9%), but with a lower (49.1%) positive

predictive value and a higher (79.5%) negative predictive value when it came to predicting the likelihood of HDP.

In a similar vein to our study, Chyad et al. [10] also discovered significant variations in uterine artery Doppler parameters, specifically the pulsatility index (PI) and resistance index (RI). Their findings revealed that women with preeclampsia had an average RI of 0.77 ± 0.07 , whereas women without preeclampsia had an average RI of 0.60 ± 0.09 . The sensitivity and specificity of their study aligned with ours for PI (90.0% and 87.0%), but were lower for RI (60.0% and 87.0%), respectively. However, this disparity in outcomes may be attributed to their limited sample size.

In a study by Barati et al. [13], 379 women underwent a uterine artery Doppler scan during the 16th to 22nd weeks of gestation. The results showed that the pulsatility index (PI) had a sensitivity of 79%, which was lower than our findings, but a similar specificity of 95.5%, positive predictive value of 88.4%, and negative predictive value of 98.9%.

However, research by Sahoo et al. [14] showed that the Resistance index (RI) has a 77.8 percent sensitivity and an equally high 85.5 percent specificity. Although the negative predictive value was higher (92.2%), the positive predictive value was lower (63.6%). The Pulsatility index (PI), in contrast, was only 44.4 percent sensitive and 89.75 percent specific. There was a 58.53% positive predictive value and an 83.24% negative predictive value. Nagar et al. [15] also observed that a RI value above 0.69 had a 94.77 percent specificity and a 40 percent sensitivity.

Additionally, a study conducted by Padmalatha et al. [16] yielded similar results to our study regarding the uterine artery (PI) and (RI) specificity of 92% but with a lower sensitivity of 60% compared to our findings.

Likewise, Rupnawar et al. [17] observed that the sensitivity and positive predictive value for RI as a predictor of preeclampsia ($RI > 0.58$) were lower, while the specificity and negative predictive value were higher (93.9% and 96.9% respectively). It's possible that the RI cutoff was set too low, which would explain this disparity.

Being a multicenter study is considered a powerful point in our study however small sample size is considered an obvious limitation of this study.

CONCLUSION

We concluded that Uterine artery Doppler between 19-26 weeks of gestation is a simple rapid non-invasive procedure, and it can be used as a reliable indicator for the prediction of preeclampsia to use as a screening test. RI was a significant predictor for Uterine artery Doppler at a cutoff value of >0.58 with AUC 0.951 with 95% Sensitivity and 93.8% Specificity. PI was a significant predictor for Uterine artery Doppler at a cutoff value of >1.1 with AUC.

CONFLICT OF INTEREST

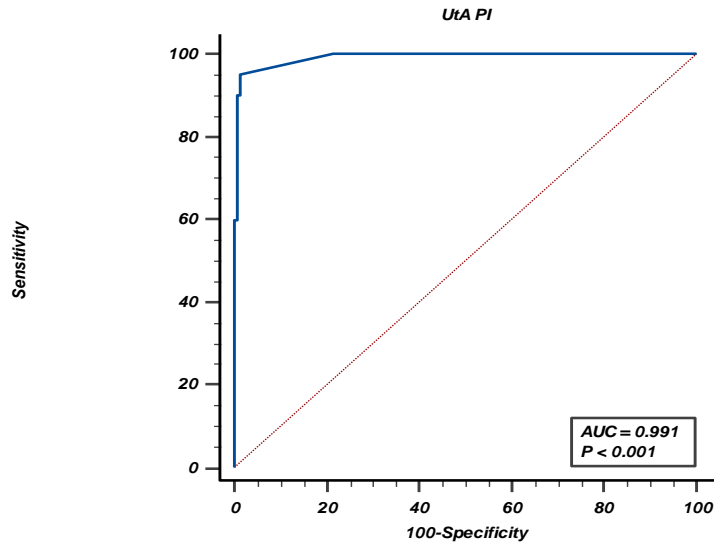
No potential conflict of interest was reported by the authors.

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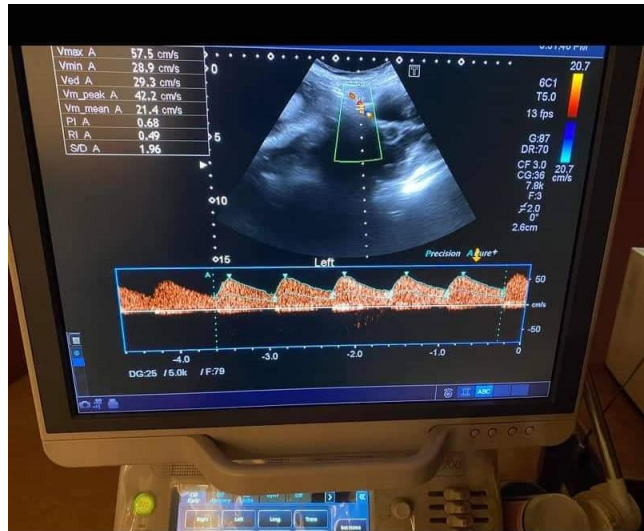
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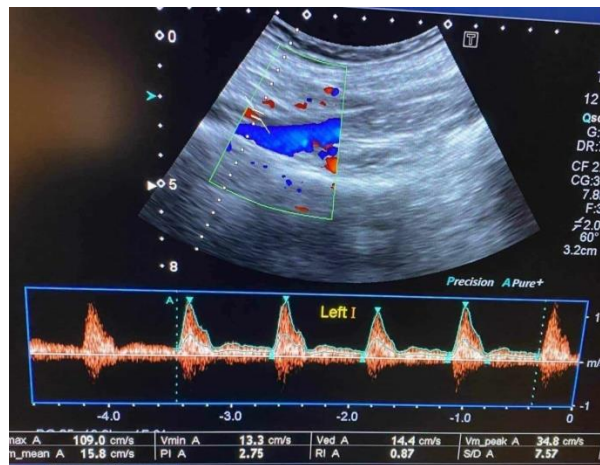
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S1: ROC curve of PI in prediction of preeclampsia.



S2: showing normal uterine artery Doppler indices in a case who continued normally till the end of pregnancy.



S3: showing high uterine artery Doppler indices in a case who developed preeclampsia.