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Diagnostic Accuracy of First Trimester Uterine Artery Doppler Ultrasonography in Predicting Pre-Eclampsia in High Risk Patients, Taking Development of Pre-Eclampsia as Gold Standard

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ABSTRACT

Objective: To determine the diagnostic accuracy of first trimester uterine artery Doppler ultrasonography in predicting pre-eclampsia in high risk patients, taking development of pre-eclampsia as gold standard. **Study type:** Cross-sectional (validation) study. **Place of study:** Department of Radiology, Shalamar Hospital, Lahore. **Duration of study:** January 2025 to May 2025. **Methodology:** 116 high-risk women (past or family history of pre-eclampsia, diabetes mellitus, age greater than 30, or history of PCOS) with singleton pregnancies of gestational age ≤14 weeks were included. Women with persistent hypertension and those with several pregnancies were not included. The uterine artery was then located at the uterocervical junction, where it seemed to cross the external iliac artery, and a transabdominal uterine artery Doppler was performed using a GE ultrasound machine and a curvilinear probe (3.5 MHz). A waveform of high quality was achieved by employing an insonation angle of less than 60°. Results of the calculation of the resistive index were recorded. Pre-eclampsia was observed in all women until delivery. **Results:** Pre-eclampsia was identified by uterine artery Doppler ultrasonography in the first trimester with a diagnostic accuracy 88.79%, a sensitivity 92.54%, a specificity 83.67%, a PPV 88.57%, and an NPV 89.13%. **Conclusion:** Our research highlights the potential of uterine artery Doppler screening in the first trimester, specifically RI values, as very useful predictors of preeclampsia.

INTRODUCTION

Pre-eclampsia is a diverse condition that can present with a range of maternal and fetal symptoms. Preeclampsia and eclampsia are linked to 10-15% of maternal deaths globally, while preeclampsia complicates 3%–8% of births.[1] Pre-eclampsia is still a severe pregnancy complication that can result in high rates of maternal and newborn mortality and morbidity, even in the age of modern obstetrics. Reliable screening tests for the prediction of these negative sequelae are still missing, despite advancements in medical research.[2] Children born to mothers who had preeclampsia and were small at birth are more likely to have a stroke, coronary heart disease, and metabolic syndrome as adults. However, preeclampsia in the mother can lead to heart disease later in life.[3]

Early detection of PE during pregnancy is essential for the planning of suitable treatment and management monitoring, just like for any other ailment. If PE is identified early, complications can be successfully managed.[4] When PE is predicted or screened using ultrasonography (U/S), it has been found that inadequate spiral artery transformation is a result of poor placentation.[5] Compared to non-PE pregnancies, vascular histopathology and placental villi lesions are four to seven times more prevalent in PE pregnancies.[6] They are linked to a rise in the resistance to flow in the uterine artery. Doppler U/S can be used to measure the impedance (resistance) to the flow of uterine arteries, which can help us understand and measure the transition of incomplete spiral arteries.[7] The study indicated that Doppler U/S could predict PE with 71.4% sensitivity, 26.3% specificity, 23.8% PPV, and 74.1% NPV.[8] In a different study, 30.3% of patients developed pre-eclampsia, and the sensitivity and specificity of the Doppler RI index were 90.0% and 87.0%, respectively.[9]

Even though there have been earlier research on this topic, as previously mentioned, the findings of those studies have been inconsistent, thus the data needs to be reexamined. Considering the development of pre-eclampsia as the gold standard, I have chosen to carry out this study in order to ascertain the diagnostic accuracy of uterine artery Doppler ultrasonography in predicting pre-eclampsia in high-risk individuals. My study's findings will be a valuable contribution to the body of research already in existence, and Doppler waveform investigations will identify pre-eclampsia early on, allowing for appropriate

therapy of these high-risk women to reduce maternal and fetal morbidity and mortality.

METHODOLOGY

116 high-risk women (past or family history of pre-eclampsia, diabetes mellitus, age greater than 30, or H/o PCOS) with singleton pregnancies of gestational age ≤14 weeks who presented to the Radiology Department of Shalamar Hospital, Lahore, were the subjects of this descriptive, cross-sectional study. With a 95% confidence level, 10% intended precision for uterine artery Doppler sonography sensitivity of 90.0%[9] and specificity of 87.0%[9], and an assumed prevalence of pre-eclampsia of 30.3%[9], a sample size of 116 cases has been determined. Patients were selected using a non-random consecutive sampling technique. Women with persistent hypertension and those with several pregnancies were not included.

In addition to being assured that there are no inherent hazards associated with their participation in this research endeavor, the patients who were participating were briefed on the purpose and advantages of the study. Age, parity, gestational age, and risk factors were recorded following informed permission. The uterine artery was then located at the uterocervical junction, where it seemed to cross the external iliac artery, and a transabdominal uterine artery Doppler was performed using a GE ultrasound machine and a curvilinear probe (3.5 MHz). A waveform of high quality was achieved by employing an insonation angle of less than 60°. Results of the calculation of the resistive index were recorded. Pre-eclampsia was classified as positive on the uterine artery if the RI was 0.58 or higher. In the presence of the researcher, a consultant radiologist with at least three years of post-fellowship experience conducted each ultrasound examination. Pre-eclampsia was observed in all women until delivery.

Software called SPSS 25.0 was used to evaluate the data that was gathered. The mean ± SD of age and gestational age were displayed. Risk factors include parity (primiparous or multiparous), pre-eclampsia on the uterine artery, age over 30, a family history of pre-eclampsia or diabetes mellitus, and a H/o PCOS. Doppler sonography and pre-eclampsia development (yes/no). Sen, sp, PPV, NPV, and diagnostic accuracy of the first trimester uterine artery were calculated using a 2x2 contingency table. Pre-eclampsia development is the gold standard for predicting pre-eclampsia in high-risk patients using Doppler ultrasonography.

Pre-eclampsia on uterine artery Doppler ultrasonography		Actual preeclampsia	
		Yes	No
	Yes	TP	FP
	No	FN	TN

RESULTS

Participants in the study were between the ages of 18 and 45, with a mean age of 28.27 ± 4.15 years. Of the patients, 74 (63.79%) were between the ages of 18 and 30, according to Table I. The average gestational age was 2.36 weeks, or 9.77 weeks. Table I displays the distribution of patients with different factors.

Of those who tested positive for them on uterine artery Doppler ultrasonography, 62 patients (True Positive) had pre-eclampsia, while 8 patients (False Positive) did not develop pre-eclampsia. Five (False Negative) and forty-one (True Negative) of the forty-six patients with negative uterine artery Doppler ultrasonography results developed pre-eclampsia, as indicated in Table II (p=0.0001). Pre-eclampsia was identified by uterine artery Doppler ultrasonography in the first trimester with a diagnostic accuracy 88.79%, a sensitivity 92.54%, a specificity 83.67%, a PPV 88.57%, and an NPV 89.13%. Table III displays the stratification of diagnostic accuracy by age, gestational age, parity, and risk variables.

Table I

Distribution of patients with other confounding variables (n=116)

		Frequency	%age
Age (years)	18-30	74	63.79
	31-45	42	36.21
Gestational age (weeks)	≤10	66	56.90
	>10	50	43.10
Parity	Primiparous	43	37.07
	Multiparous	73	62.93
Risk factor	F/h of pre-eclampsia	24	20.69
	DM	31	26.72
	Age >30 years	42	36.21
	h/o PCOS	19	16.38

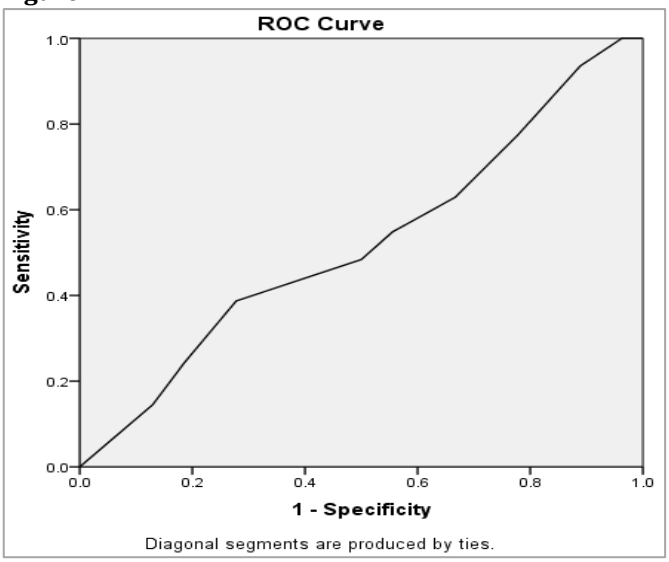
Table II

Diagnostic accuracy of first trimester uterine artery Doppler ultrasonography in predicting pre-eclampsia in high risk patients, taking development of pre-eclampsia as gold standard.

	Actual pre-eclampsia (+ive)	Actual pre-eclampsia (-ive)	P-value
Pre-eclampsia on uterine artery Doppler USG (+ive)	62 (True positive)	08 (False Positive)	0.0001
Pre-eclampsia on uterine artery Doppler USG (-ive)	05 (False negative)	41 (True Negative)	

Sensitivity: 92.54%
Specificity: 83.67%
Positive Predictive Value (PPV): 88.57%
Negative Predictive Value (NPV): 89.13%
Diagnostic Accuracy: 88.79%

Figure 1



Area under the curve = 0.522

Table III

Stratification of diagnostic accuracy with respect to age, gestational age, parity and risk factors.

		Sensitivity	Specificity	PPV	NPV	DA	
Age (years)	18-30	91.11%	86.67%	91.11%	86.67%	89.33%	0.001
	31-45	95.24%	71.43%	76.92%	93.75%	83.33%	0.001
GA (weeks)	≤10	96.55%	81.48%	84.85%	95.65%	89.29%	0.001
	>10	88.89%	85.71%	92.31%	80.0%	87.80%	0.001
Parity	Primiparous	91.43%	85.71%	88.89%	88.89%	88.89%	0.001
	Multiparous	95.24%	76.92%	86.96%	90.91%	88.24%	0.001
Risk factor	F/h of pre-eclampsia	96.67%	90.0%	93.55%	94.74%	94.0%	0.001
	DM	88.46%	76.19%	82.14%	84.21%	82.98%	0.001
	Age >30 years	95.24%	71.43%	76.92%	93.75%	83.33%	0.001
	h/o PCOS	91.43%	95.0%	96.97%	86.36%	92.73%	0.001

DISCUSSION

Our study's main goal was to assess the effectiveness of uterine artery Doppler sonography screening in the first trimester, specifically in predicting preeclampsia by combining biochemical and clinical factors. Our results demonstrate the critical significance of PI and RI in early diagnosis through thorough analysis, which represents a major advancement in prenatal care.[10-13]

The average RI values for the left and right uterine arteries in our investigation were 0.58, with a little standard deviation variation. Between weeks 11 and 13 of pregnancy, the PI levels showed a significant decline that was statistically significant ($p < 0.05$). On the other hand, RI values fluctuated insignificantly throughout the same time period ($p > 0.05$).

The results of our investigation are congruent with those of other studies, like Gomez et al.[14], which similarly found consistent PI measurements over comparable gestational weeks. The consistency of PI as a marker in early pregnancy evaluations is highlighted by this similarity. The establishment of cutoff thresholds for PI and RI in the prediction of preeclampsia emphasizes the diagnostic accuracy and predictive usefulness of these indices in addition to their diagnostic precision. The resilience of PI and RI in early detection techniques is demonstrated by the sensitivity, specificity, PPV, NPV, and total diagnostic accuracy values.[15]

Furthermore, our analysis of the PI and RI cutoff levels in relation to gestational hypertension shows important diagnostic potential. Preeclampsia and gestational hypertension, however, have rather different PPVs. This disparity emphasizes how difficult it is to distinguish between preeclampsia and gestational hypertension using these indices, highlighting the urgent need for specialized screening procedures. When compared to earlier research, including that conducted by Khanam et al[16], our study's sensitivity for identifying preeclampsia using mean PI is higher. This disparity indicates how our knowledge and use of these indices in prenatal screening have changed over time. Additionally, comparisons with research by Oancea et al. and Abdel Moety et al.[17,18] indicate diverse conclusions resulting from distinct research approaches and demographic variables, clarifying differences in specificity and sensitivity rates.

Our findings have a contextual background thanks to the research done by Khanam et al. and Shahid et al.[16,19] The predictive accuracy of uterine artery PI in the screening for preeclampsia and gestational hypertension is shown by the ROC AUC values presented in these studies. When contrasted to the findings of Shahid et al[19], the observed discrepancy in sensitivity and specificity measures emphasizes how prenatal screening research is changing. The importance of uterine artery Doppler indices in early pregnancy screening is further supported by the congruence of our work with these more general research trends.

Our work highlights the modest variations in predicting gestational hypertension and preeclampsia and adds to the increasing body of evidence in favor of the use of uterine artery Doppler sonography in early pregnancy screening. Future research directions are guided by the diagnostic accuracy across RI indices that have been highlighted. To enhance prenatal treatment and results, a cooperative approach integrating clinical, biochemical, and sonographic factors is required. The knowledge gained from this study helps us to manage the challenges of early pregnancy screening and pave the way for the best possible outcomes for both the mother and the fetus.

This study showed a number of noteworthy advantages. The use of first-trimester uterine artery Doppler ultrasonography for the early identification of preeclampsia is one of its main advantages. Robust statistical measurements including sensitivity, specificity, and AUC values corroborate the RI's noteworthy high predictive accuracy. By providing useful benchmarks for early diagnosis and intervention, the determination of certain cutoff values for RI makes a fresh addition to the corpus of current research. These results have significant therapeutic ramifications, indicating that by facilitating the early identification and treatment of possible issues, integrating these Doppler ultrasonography parameters into standard prenatal care may enhance outcomes for pregnancies at risk.

However, this study has a number of shortcomings. The results may not be as applicable to different populations and clinical situations because the study was only carried out at one location. Furthermore, even though the 116-person sample size yielded useful data, a bigger sample size might improve the results' dependability and robustness. Another drawback is that notching assessment is not included in Doppler ultrasound exams, which may cause some high-risk patients to be missed. Lastly, our capacity to evaluate the screening method's predictive reliability and long-term effects is limited by the absence of longitudinal data, such as prenatal and postnatal follow-up. These restrictions point to areas that need more investigation to confirm and build on these results.

By facilitating the early identification of preeclampsia and gestational hypertension, implications, such as the use

of uterine artery Doppler ultrasound in the first trimester, can enhance prenatal care. For at-risk mothers, early identification enables prompt therapies, improving pregnancy outcomes. By integrating this screening tool into standard prenatal care procedures, the likelihood of unfavorable outcomes may be decreased and more individualized and efficient management techniques may result.

Validating these results in bigger, more varied populations should be the main goal of future studies. Understanding the long-term advantages of early detection will be aided by studies that use longitudinal data to monitor prenatal and postnatal outcomes. A more thorough risk assessment might be obtained by looking at the incorporation of notching assessment into Doppler evaluations. These initiatives will expand on the current research and help improve preeclampsia and gestational hypertension screening and treatment procedures.

CONCLUSION

Our research highlights the potential of uterine artery Doppler screening in the first trimester, specifically RI values, as very useful predictors of preeclampsia. These findings significantly contribute to the improvement of prenatal care practices by having important ramifications for early detection and management techniques in pregnancies deemed at risk. The findings' practical implications for clinical practice are examined, with a focus on how uterine artery Doppler use during the first trimester can enhance prenatal care and outcomes for pregnancies that are at risk. Based on the results and limits of our study, we also recommend particular areas for further research, exhibiting a forward-thinking mindset and placing our work within the context of ongoing research initiatives.

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