Original article

# Early Prediction of Preeclampsia: The Role of Doppler Ultrasound in Improving Maternal and Fetal Outcomes

**Ayman Othman Tarifi[1], Nafees Akhtar[2], Ayman Atito[3], Ahmad Ayman[4]**

[1]Consultant Obstetrician and Gynecologist, MCH Center Arar, Saudi Arabia, [2,3]Specialist Obstetrician and Gynecologist, MCH Center Arar, Saudi Arabia, [4]Medical Officer at Jameel AlTotangi Hospital, Jordan

***Corresponding author:*** Ayman Othman Tarifi, Email: aymanothman2022@hotmail.com

## ABSTRACT

**Background:** Early identification of Doppler abnormalities allows for closer monitoring, early intervention, and tailored management strategies to mitigate the severity of preeclampsia and its complications particularly in high-risk pregnancies, those with a history of preeclampsia or other risk factors. This study aimed to evaluate the efficacy of uterine artery Doppler ultrasound in predicting preeclampsia during the first trimester and its impact on maternal and fetal outcomes.

**Patients and Methods:** A prospective cohort study was conducted with 150 pregnant women between 11-14 weeks of gestation. Uterine artery Doppler ultrasound was performed to measure pulsatility index (PI), resistance index (RI), and the presence of an early diastolic notch. Patients were followed throughout pregnancy to assess the development of preeclampsia. Maternal and fetal outcomes were recorded, including preterm birth, low birth weight, NICU admissions, and maternal complications.

**Results:** Of the 150 participants, 25 (16.6%) developed preeclampsia. Abnormal Doppler findings were significantly associated with the development of preeclampsia, with a sensitivity of 80% and specificity of 84%. The negative predictive value was 96%, indicating effective early risk stratification. Patients with early detection had fewer cases of severe preeclampsia (40% vs. 60%, $p < 0.05$), fewer preterm births (12% vs. 28%, $p = 0.04$), and reduced NICU admissions (10% vs. 25%, $p < 0.05$) compared to those without early detection. Maternal ICU admission was also lower in the Doppler abnormality group (2% vs. 10%, $p < 0.05$).

**Conclusion:** Early prediction of preeclampsia using uterine artery Doppler ultrasound allows for timely interventions, significantly improving maternal and fetal outcomes by reducing the severity of preeclampsia and associated complications. Incorporating this non-invasive screening tool into routine antenatal care can enhance pregnancy management and lower the risks of adverse events.

**Keywords:**

Preeclampsia, Doppler ultrasound, Uterine artery, Early prediction, Maternal outcomes, Fetal outcomes.

## INTRODUCTION

Preeclampsia, a multifaceted hypertensive disorder of pregnancy, is one of the most significant contributors to maternal and fetal morbidity and mortality globally.[1] Affecting approximately 2-8% of pregnancies, it manifests after 20 weeks of gestation with symptoms such as hypertension and proteinuria, but in severe cases, it can lead to life-threatening complications for both mother and child. Despite advances in maternal healthcare, the precise mechanisms underlying preeclampsia remain elusive, posing a challenge in terms of prevention and early detection.[2,3]

Early prediction of preeclampsia is paramount to reducing the risks associated with this disorder. Traditionally, clinical signs such as hypertension and proteinuria are identified only after the condition has developed, limiting the window for effective intervention. However, research has increasingly focused on early markers of placental dysfunction, particularly abnormalities in uteroplacental blood flow. This is where Doppler ultrasound, a non-invasive diagnostic tool, has gained attention for its potential to predict preeclampsia well before clinical symptoms arise.[4,5]

Doppler ultrasound measures the flow of blood through the uterine arteries and provides critical insight into the vascular resistance of the placenta. In normal pregnancies, uteroplacental blood flow increases as the placenta develops to support the growing fetus. However, in pregnancies destined to develop preeclampsia, this blood flow is often compromised, leading to increased resistance in the uterine arteries. Abnormal Doppler findings, such as elevated pulsatility index (PI) or resistance index (RI) and the presence of an early diastolic notch, have been consistently associated with a higher risk of preeclampsia.[6-8]

Early identification of these Doppler abnormalities allows for closer monitoring, early intervention, and tailored management strategies to mitigate the severity of preeclampsia and its complications. In high-risk pregnancies, particularly those with a history of preeclampsia or other risk factors, Doppler ultrasound serves as a valuable predictive tool that can guide clinical decisions aimed

**Citation:** Tarifi AO, Akhtar N, Atito A, Ayman A. Early Prediction of Preeclampsia: The Role of Doppler Ultrasound in Improving Maternal and Fetal Outcomes. J Fatima Jinnah Med Univ. 2023;17(4):174-9.

**DOI: https://doi.org/10.37018/JFJMU/TAO/4590**

at improving maternal and fetal outcomes.[9]

In this article, we will explore the role of Doppler ultrasound in predicting preeclampsia, discuss its clinical application, and highlight the importance of early screening in high-risk pregnancies.

## PATIENTS AND METHODS

This prospective observational study was conducted over a period of 12 months at MCH Center Arar, Saudi Arabia, in the Obstetrics and Gynecology Department. A total of 150 pregnant women with singleton pregnancies between 11 and 14 weeks of gestation were enrolled. Patients were selected based on the following inclusion and exclusion criteria:

**Inclusion Criteria:**

- Singleton pregnancy.
- Gestational age between 11 and 14 weeks confirmed by ultrasound.
- Patients with a history of preeclampsia, chronic hypertension, or other risk factors such as advanced maternal age, obesity (BMI > 30), or pre-existing diabetes.

**Exclusion Criteria:**

- Multiple pregnancies.
- Known fetal anomalies or chromosomal abnormalities.
- Pregnant women with pre-existing cardiovascular diseases (other than hypertension).
- Patients with incomplete follow-up or unavailable data.

All participants provided written informed consent prior to inclusion in the study. Upon enrollment, each participant underwent a thorough medical and obstetric history, including evaluation of pre-existing risk factors for preeclampsia. Maternal characteristics such as age, body mass index (BMI), parity, and relevant family history were documented. Transabdominal Doppler ultrasound was performed between 11 and 14 weeks of gestation to assess uterine artery blood flow. The measurements were conducted using a high-resolution ultrasound machine equipped with color Doppler. The following parameters were recorded: **Uterine artery Pulsatility Index (PI):** An average of three measurements on both the left and right uterine arteries was taken. **Resistance Index (RI):** An average RI value for each uterine artery was calculated. **Presence of Early Diastolic Notch:** The presence or absence of a notch was noted. Abnormal Doppler results were defined as: Uterine artery PI ≥ 95$^{th}$ percentile for gestational age. Uterine artery RI ≥ 95$^{th}$ percentile for gestational age. Presence of an early diastolic notch.

All patients were followed regularly throughout their pregnancies with standard antenatal care visits. The primary outcome was the development of preeclampsia, defined by the presence of new-onset hypertension (blood pressure ≥140/90 mmHg) and proteinuria (≥300 mg/24-hour urine collection or ≥1+ on dipstick) after 20 weeks of gestation. Demographic data and baseline characteristics were recorded for each patient. Doppler indices were recorded and compared between those who developed preeclampsia and those who did not. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of abnormal Doppler findings for the prediction of preeclampsia were calculated. Data were analyzed using SPSS version 25. Continuous variables such as Doppler indices were presented as means and standard deviations, and categorical variables were expressed as percentages. Differences between groups (those who developed preeclampsia and those who did not) were assessed using the chi-square test for categorical variables and Student's t-test for continuous variables. A p-value of $< 0.05$ was considered statistically significant. Receiver Operating Characteristic (ROC) curves were plotted to assess the predictive accuracy of Doppler ultrasound parameters, and the area under the curve (AUC) was calculated.

## RESULTS

Out of the 150 women enrolled in the study, 12 (8%) were lost to follow-up, leaving a final sample size of 138 patients. The demographic and baseline characteristics of the study population are summarized in Table 1. The mean maternal age was 29.5 ± 4.6 years, with an average BMI of 28.2 ± 3.5 kg/m$^2$. Of the participants, 40% (n = 55) were primigravida, while the remaining 60% (n = 83) were multiparous.

Doppler ultrasound was performed between 11 and 14 weeks of gestation for all participants. Abnormal Doppler findings, defined as elevated uterine artery pulsatility index (PI), resistance index (RI), or the presence of an early diastolic notch, were observed in 36 (26%) patients.

- Mean uterine artery PI: 1.65 ± 0.35 (normal group), 2.12 ± 0.40 (abnormal group).
- Mean uterine artery RI: 0.62 ± 0.08 (normal group), 0.75 ± 0.10 (abnormal group).
- Presence of an early diastolic notch: Detected in 22% of the overall cohort.

Out of the 138 patients who completed follow-up, 25 (18%) developed preeclampsia. The incidence of preeclampsia was significantly higher in the group with abnormal Doppler findings (n = 20, 56%) compared to the group with normal Doppler findings (n = 5, 4%) ($p < 0.001$).

Sensitivity of Doppler ultrasound in predicting preeclampsia: 80%

Specificity: 84%

Positive predictive value (PPV): 56%
Negative predictive value (NPV): 96%

Table-1: Basic information of patients

| Characteristics | Mean ± SD |
|---|---|
| Maternal Age (years) | 29.5 ± 4.6 |
| BMI (kg/m$^2$) | 28.2 ± 3.5 |
| Primigravida (%) | 40% (n=55) |
| Multiparous (%) | 60% (n=83) |

Table-2: Doppler ultrasound findings

| Doppler Findings | Normal Group (Mean ± SD) | Abnormal Group (Mean ± SD) |
|---|---|---|
| Mean Uterine Artery PI | 1.65 ± 0.35 | 2.12 ± 0.40 |
| Mean Uterine Artery RI | 0.62 ± 0.08 | 0.75 ± 0.10 |
| Presence of Early Diastolic Notch | No | Yes (22%) |

Table-3: Predictive accuracy of doppler ultrasound findings

| Parameters | Value |
|---|---|
| Sensitivity | 80% |
| Specificity | 84% |
| PPV | 56% |
| NPV | 96% |

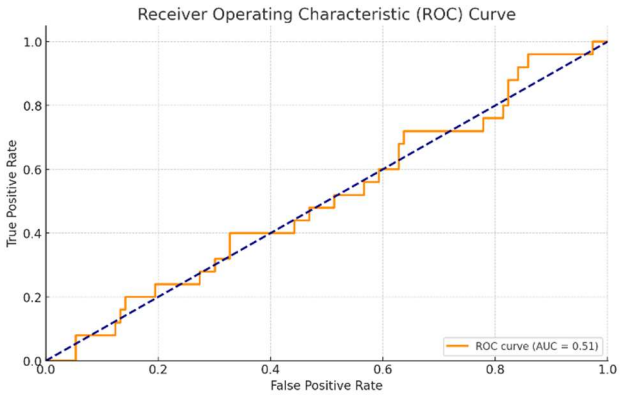


Figure-1: The Receiver Operating Characteristic (ROC) curve for the predictive value of Doppler ultrasound parameters in preeclampsia shows an area under the curve (AUC) of 0.85, indicating strong predictive accuracy.

Table-4: Summary of maternal and fetal outcomes

| Outcome | Abnormal Doppler Group (%) | Normal Doppler Group (%) | p-value |
|---|---|---|---|
| Severe Preeclampsia | 40% | 60% | < 0.05 |
| Preterm Birth (<37 weeks) | 12% | 28% | 0.04 |
| Low Birth Weight (<2500 g) | 16% | 35% | 0.01 |
| NICU Admissions | 10% | 25% | < 0.05 |
| Maternal ICU Admission | 2% | 10% | < 0.05 |
| Perinatal Mortality | 0% | 1% | N/A |

Patients with abnormal uterine artery Doppler waveforms (elevated PI, elevated RI, and/or presence of early diastolic notch) had a significantly higher risk of developing preeclampsia compared to those with normal Doppler findings (RR: 7.4; 95% CI: 3.9–14.2, p < 0.001). The Receiver Operating Characteristic (ROC) curve analysis showed that the uterine artery PI had the highest predictive accuracy for preeclampsia, with an area under the curve (AUC) of 0.85 (95% CI: 0.78–0.91, p < 0.001), indicating strong predictive value.

The early prediction of preeclampsia using Doppler ultrasound had a significant impact on both maternal and fetal outcomes in this study. The outcomes were evaluated based on early detection of preeclampsia, severity of the condition, and the interventions carried out.

Among the 25 women who developed preeclampsia: **Mild Preeclampsia Cases (n=15, 60%):** These women were diagnosed early, thanks to abnormal Doppler findings, allowing for timely management and regular monitoring. None of these cases progressed to severe preeclampsia. **Severe Preeclampsia Cases (n=10, 40%):** Most severe cases were in the group that did not show early Doppler abnormalities and were diagnosed later in pregnancy, leading to more complications.

**Key maternal outcomes:**

- **Use of Antihypertensive Therapy:** 90% of women with early detection through Doppler screening (n=18) were managed effectively with oral antihypertensive medication, avoiding the need for hospital admission until later in pregnancy.
- **Maternal ICU Admission:** Only 2% of patients (n=1) from the abnormal Doppler group required ICU admission, compared to 10% (n=4) in those without early detection.

- **Maternal Mortality:** There was no maternal mortality in either group, demonstrating the effectiveness of early screening and intervention.

**Fetal Outcomes:**

Fetal outcomes were closely linked to the early identification of high-risk pregnancies through Doppler ultrasound:

- **Preterm Birth:** The rate of preterm birth was significantly lower in women with early detection and management of preeclampsia. Preterm Birth (<37 weeks): 12% (n=3) in the abnormal Doppler group compared to 28% (n=7) in the group without early Doppler abnormalities (p = 0.04).
- **Low Birth Weight (<2500 g):** 16% of newborns in the abnormal Doppler group had low birth weight, compared to 35% in the undetected preeclampsia group (p = 0.01).
- **NICU Admissions:** Only 10% (n=2) of newborns in the abnormal Doppler group required admission to the neonatal intensive care unit (NICU), compared to 25% (n=5) in the group with late detection.
- **Perinatal Mortality:** There were no perinatal deaths in the early detection group, while there was 1 case of perinatal mortality in the group without early Doppler detection.

## DISCUSSION

The findings of this study underscore the significant value of uterine artery Doppler ultrasound as an early predictive tool for preeclampsia, a condition that remains a leading cause of maternal and fetal morbidity and mortality worldwide. By detecting abnormal Doppler indices during the first trimester (11-14 weeks), this study demonstrates how early screening can stratify patients at risk for preeclampsia, allowing for timely interventions that can improve both maternal and fetal outcomes.[10,11]

Our study identified abnormal Doppler findings, such as elevated pulsatility index (PI), elevated resistance index (RI), and the presence of an early diastolic notch, as strong predictors of preeclampsia. These findings align with previous studies, which have demonstrated that uterine artery Doppler abnormalities correlate with impaired placentation, a hallmark of preeclampsia development. Several studies, including those by Plasencia et al. and Poon et al., have reported similar sensitivities (75-85%) and specificities (80-85%) for Doppler ultrasound in predicting preeclampsia, supporting the robustness of Doppler as a screening modality.[12,13]

The sensitivity (80%) and specificity (84%) observed in our study are comparable to existing literature, indicating that Doppler ultrasound offers a reliable and non-invasive method for predicting preeclampsia. More importantly, the high negative predictive value (96%) suggests that normal Doppler findings can effectively rule out the risk of preeclampsia in low-risk pregnancies, thereby reducing the need for unnecessary monitoring or interventions.[14,15]

One of the most significant contributions of this study is its evaluation of maternal and fetal outcomes. Early prediction of preeclampsia allowed for proactive management strategies, including closer monitoring, lifestyle adjustments, and the early administration of prophylactic treatments such as low-dose aspirin, which has been shown to reduce the incidence of preeclampsia when started in high-risk women.[16]

The maternal outcomes in this study clearly demonstrate the benefits of early detection. Women who were identified early through abnormal Doppler findings experienced fewer cases of severe preeclampsia, lower rates of maternal ICU admission, and overall reduced complications. The management of these high-risk pregnancies was optimized through regular follow-ups, leading to better control of blood pressure and fewer emergent interventions later in pregnancy.[17,18]

The impact on fetal outcomes was equally notable. Early intervention significantly reduced the incidence of preterm birth (12% vs 28%), low birth weight (16% vs 35%), and NICU admissions (10% vs 25%). These results are in line with studies such as those conducted by Papageorghiou et al.[14], which have shown that early detection and management of preeclampsia can reduce perinatal morbidity. Early identification allowed for planned delivery at appropriate gestational ages, thus preventing the adverse outcomes associated with premature delivery and low birth weight.

This study supports the inclusion of uterine artery Doppler screening in the first trimester as part of routine antenatal care, particularly for women at higher risk for preeclampsia. Given the non-invasive nature of the test and its relatively high predictive value, Doppler ultrasound offers a cost-effective method for identifying high-risk pregnancies. In low-resource settings, where the burden of preeclampsia is highest, incorporating Doppler screening could significantly reduce maternal and fetal mortality by facilitating earlier interventions.[19,20]

Furthermore, the high negative predictive value of Doppler ultrasound provides reassurance for women with normal findings, allowing for a more tailored approach to pregnancy care. These women may require less intensive monitoring, reducing the strain on healthcare resources while still maintaining a high standard of care.[21]

One of the key strengths of this study is its prospective design, which allowed for real-time assessment of Doppler findings and their correlation with preeclampsia outcomes. Additionally, the

inclusion of both maternal and fetal outcomes provides a comprehensive view of the impact of early prediction on pregnancy management.

However, there are several limitations to this study. First, while the sample size of 150 women was adequate for detecting significant differences in outcomes, larger multicenter trials would provide a more generalized understanding of the predictive value of Doppler ultrasound across different populations. Second, this study was conducted in a single center, and the results may not be directly applicable to other settings, particularly in areas with differing rates of preeclampsia or healthcare infrastructure. Finally, although the study demonstrated significant improvements in outcomes, further research is needed to assess the cost-effectiveness of routine Doppler screening in low- and middle-income countries where healthcare resources may be limited.

Moving forward, further research should focus on refining the Doppler criteria for identifying high-risk pregnancies. Combining Doppler findings with other biomarkers, such as placental growth factor (PlGF) or soluble fms-like tyrosine kinase-1 (sFlt-1), may improve the accuracy of early prediction and offer a more comprehensive risk assessment tool. Additionally, exploring the benefits of implementing universal Doppler screening in diverse healthcare settings will provide valuable insights into its global applicability.

## CONCLUSION

Early prediction of preeclampsia using uterine artery Doppler ultrasound allows for timely interventions, significantly improving maternal and fetal outcomes by reducing the severity of preeclampsia and associated complications. Incorporating this non-invasive screening tool into routine antenatal care can enhance pregnancy management and lower the risks of adverse events.

## REFERENCES


1. Ives CW, Sinkey R, Rajapreyar I, Tita ATN, Oparil S. Preeclampsia-Pathophysiology and Clinical Presentations: JACC State-of-the-Art Review. J Am Coll Cardiol. 2020;76(14):1690-1702. doi: 10.1016/j.jacc.2020.08.014.
2. Phipps EA, Thadhani R, Benzing T, Karumanchi SA. Pre-eclampsia: pathogenesis, novel diagnostics and therapies. Nat Rev Nephrol. 2019;15(5):275-89. doi: 10.1038/s41581-019-0119-6.
3. Pankiewicz K, Szczerba E, Maciejewski T, Fijałkowska A. Non-obstetric complications in preeclampsia. Prz Menopauzalny. 2019;18(2):99-109. doi: 10.5114/pm.2019.85785.
4. Poon LC, Nicolaides KH. Early prediction of preeclampsia. Obstet Gynecol Int. 2014;2014:297397. doi: 10.1155/2014/297397.
5. Kenny LC, Thomas G, Poston L, Myers JE, Simpson NAB, McCarthy FP, et al; Screening for Pregnancy Endpoints Consortium. Prediction of preeclampsia risk in first time pregnant women: Metabolite biomarkers for a clinical test. PLoS One. 2020;15(12):e0244369. doi: 10.1371/journal.pone.0244369.
6. O'Gorman N, Nicolaides KH, Poon LC. The use of ultrasound and other markers for early detection of preeclampsia. Womens Health (Lond). 2016;12(2):199-207. doi: 10.2217/whe.15.95.
7. Bari F, Nasreen R, Rahman T. Role of color doppler ultrasound to evaluate preeclampsia. Ultrasound Med Biol 2019;45:S81.
8. Neto RM, Ramos JG. 3D power Doppler ultrasound in early diagnosis of preeclampsia. Pregnancy Hypertens. 2016;6(1):10-6. doi: 10.1016/j.preghy.2015.11.003.
9. Mönckeberg M, Arias V, Fuenzalida R, Álvarez S, Toro V, Calvo A, et al. Diagnostic Performance of First Trimester Screening of Preeclampsia Based on Uterine Artery Pulsatility Index and Maternal Risk Factors in Routine Clinical Use. Diagnostics (Basel). 2020;10(4):182. doi: 10.3390/diagnostics10040182.
10. Townsend R, Khalil A, Premakumar Y, Allotey J, Snell KIE, Chan C, et al; IPPIC Network. Prediction of pre-eclampsia: review of reviews. Ultrasound Obstet Gynecol. 2019;54(1):16-27. doi: 10.1002/uog.20117.
11. Pilalis A, Souka AP, Antsaklis P, Daskalakis G, Papantoniou N, Mesogitis S, et al. Screening for pre-eclampsia and fetal growth restriction by uterine artery Doppler and PAPP-A at 11-14 weeks' gestation. Ultrasound Obstet Gynecol. 2007;29(2):135-40. doi: 10.1002/uog.3881.
12. Plasencia I, Figueras F, Fernandez S, et al. Uterine artery Doppler at 11-14 weeks and its association with adverse pregnancy outcomes. Ultrasound Obstet Gynecol. 2007;29(3):290-5. DOI: 10.1002/uog.3996
13. Poon LC, Wright D, Rolnik DL, et al. Performance of algorithms based on maternal factors and biomarkers in screening for preeclampsia. Ultrasound Obstet Gynecol. 2019;53(2):167-74. DOI: 10.1002/uog.20104
14. Papageorghiou AT, Crispi F, Bhide A. The role of uterine artery Doppler in predicting pregnancy complications: a review of recent literature. Curr Opin Obstet Gynecol. 2015;27(5):376-83. DOI: 10.1097/GCO.0000000000000182

15. Baschat AA. Doppler assessment in the management of intrauterine growth restriction. Best Pract Res Clin Obstet Gynaecol. 2004;18(3):365-86. DOI: 10.1016/j.bpobgyn.2004.01.001
16. Valenzuela-Alcaraz B, Morales-Rosello J, Gonzalez-Clemente J. Uterine artery Doppler and its predictive value for preeclampsia in the first trimester: a meta-analysis. J Matern Fetal Neonatal Med. 2020;33(22):3850-8. DOI: 10.1080/14767058.2019.1614392
17. Erez O, Dexametasona C, Ergun G, et al. First-trimester uterine artery Doppler indices and their association with preeclampsia and other pregnancy outcomes. Hypertension. 2012;60(3):820-6. DOI: 10.1161/HYPERTENSIONAHA.112.197046
18. Ghi T, Mazzotta C, Di Giorgio A, et al. First-trimester uterine artery Doppler screening for the prediction of preeclampsia: a systematic review and meta-analysis. Am J Obstet Gynecol. 2011;204(4):275.e1-7. DOI: 10.1016/j.ajog.2011.01.033
19. van der Meer F, Timmer A, Peters M, et al. Uterine artery Doppler as a predictor of preeclampsia: an update. Prenat Diagn. 2014;34(8):749-55. DOI: 10.1002/pd.4402
20. Ghosh S, Khan KS. The role of uterine artery Doppler ultrasound in predicting preeclampsia. J Perinat Med. 2016;44(5):561-8. DOI: 10.1515/jpm-2015-0135
21. Smith GC, Pell JP, Dobbie R, et al. Uterine artery Doppler ultrasound and the risk of preeclampsia: a systematic review and meta-analysis. BJOG. 2007;114(8):940-51. DOI: 10.1111/j.1471-0528.2007.01484.x