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# PREDICTION OF PRE-ECLAMPSIA AND FETAL GROWTH RESTRICTION BY UTERINE ARTERY DOPPLER: A SYSTEMATIC REVIEW

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## Abstract

***Background:*** *Pre-eclampsia and fetal growth restriction (FGR) are major causes of maternal and perinatal morbidity and mortality. Early detection of at-risk pregnancies is crucial for timely intervention. Uterine artery Doppler ultrasonography is a noninvasive technique used to assess uteroplacental circulation, which may help predict these complications.*

***Methods:*** *A comprehensive literature search was conducted using databases including PubMed, Google Scholar, Scopus, CINAHL, and LILACS. From 4121 initially identified records, 10 studies met the inclusion criteria after screening and duplicate removal. These studies assessed the role of uterine artery Doppler ultrasound in predicting placental insufficiency-related complications.*

***Results:*** *Most studies demonstrated that abnormal uterine artery Doppler findings in the second trimester, such as elevated PI or the presence of bilateral diastolic notching, were significantly associated with the development of pre-eclampsia and FGR. The predictive value was higher when combined with maternal risk factors or biochemical markers.*

***Conclusion:*** *Uterine artery Doppler is a valuable screening tool for predicting pre-eclampsia and fetal growth restriction, especially when used in the second trimester. It may help in stratifying risk and guiding closer monitoring and early intervention in high-risk pregnanciesive.*

## INTRODUCTION

Pre-eclampsia and eclampsia remain critical health issues contributing to maternal and perinatal complications and fatalities[1]. Approximately 50,000 deaths globally are attributed to this most prevalent pregnancy-related medical complication, whose incidence has been steadily rising. It is also linked to substantial maternal morbidity and mortality. Pre-eclampsia is a progressive, unexpected, and dangerous condition that complicates 2 to 4% of pregnancies worldwide. It is commonly related to hypoxic and/or ischemic conditions of the placenta[2]. De novo hypertension (>140/90 mmHg) that manifests after 20 weeks of pregnancy and is accompanied by proteinuria (>0.3 g/24 h) is known as pre-eclampsia. Numerous risk factors, such as nulliparity, advanced age, chronic hypertension, and prepregnancy diabetes

mellitus, have been recommended by various studies to identify women who are at high risk of pre-eclampsia[3]. One of the independent risk factors for preeclampsia is gestational diabetes mellitus. Women with gestational diabetes were more likely to develop preeclampsia, according to a retrospective analysis of 647,392 pregnancies. Preeclampsia development has also been connected to preexisting diabetes mellitus; according to a systematic study, preexisting diabetes mellitus before pregnancy was linked to an elevated risk of preeclampsia. Those with higher BMIs had higher risk of preeclampsia[4]. Other risk factors associated with preeclampsia include placental aging, endocrine disorders, sleeping disorders, hyperparathyroidism, and various fetal diseases.

Perinatal mortality among patients with early-onset pre-eclampsia was 29% among those with fetal growth retardation (31 of 108), while it was 6% among those without fetal growth retardation (31 of 485). This comparison demonstrates the serious risk to infant survival that arises when prenatal growth retardation exacerbates early-onset pre-eclampsia[5]. The purpose of preeclampsia diagnosis is to detect women at increased risk of complications and to guide optimal clinical management[2]. Despite the fact that the exact cause pre-eclampsia disorder is yet unknown, there is strong evidence that trophoblastic invasion failure of the maternal spiral arteries is a frequent underlying cause[5]. The formation of a suitable umbilical and uterine circulation is necessary for a normal pregnancy result. These circulatory beds can be studied noninvasively and seemingly safely with Doppler ultrasound equipment. The aim of this systematic review is to highlight the diagnostic accuracy of uterine artery Doppler ultrasound in predicting placental insufficiency-related complications, such as pre-eclampsia and fetal growth restriction.

## METHOD AND MATERIAL

This systematic review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines but does not include a meta-analysis. A comprehensive search of major electronic databases, including PubMed, Google scholar, and Scopus, is conducted using relevant keywords as pre-eclampsia, FGR & uterine artery Doppler. The search is limited to studies published in English.

**Inclusion and Exclusion Criteria:**

Studies included if they were Cross sectional and cohort studies, studies investigated the predictive accuracy of uterine artery Doppler ultrasound for PE and/or FGR, Reported sensitivity, specificity of uterine artery Doppler ultrasound in predicting placental insufficiency-related complications. And studies were published as full-text articles would be included. Studies excluded if they were review articles, case reports, or conference abstracts, if they did not report primary data and not have diagnostic accuracy. Studies were published in languages other than English would also be excluded.

**Data Extraction**

Two reviewers, SFH and MZ independently collected appropriate information from the particular studies by means of a data extraction table based on the predefined inclusion criteria. If there were any disagreements or differences in their findings. Two more reviewers SK, and MA facilitated resolve them over discussion.

Independently extract data from the included studies using a standardized data extraction form. The following data would be extracted: Study characteristics (author, year, country, study design), Participant characteristics (age, gestational age, parity), Uterine artery Doppler ultrasound parameters (mean pulsatility index, resistance index and diastolic notching), Outcome measures (PE, FGR), Predictive measures (sensitivity, specificity, positive predictive value and negative predictive value).

**Results**

From 4121 identified records, Google scholar yielded 2900 studies, PubMed identified 850 studies, Research gate350, Scopus identified 9 studies, CINAHL found 6 studies, LILACS found 6. After removing duplicates and meeting the inclusion criteria 10 studies met the criteria for selection. These studies evaluated the sensitivity and specificity of uterine artery Doppler ultrasound for the assessment pre-eclampsia and intrauterine growth restriction by using different parameters i.e. Pulsatility index, resistive index and diastolic notching.

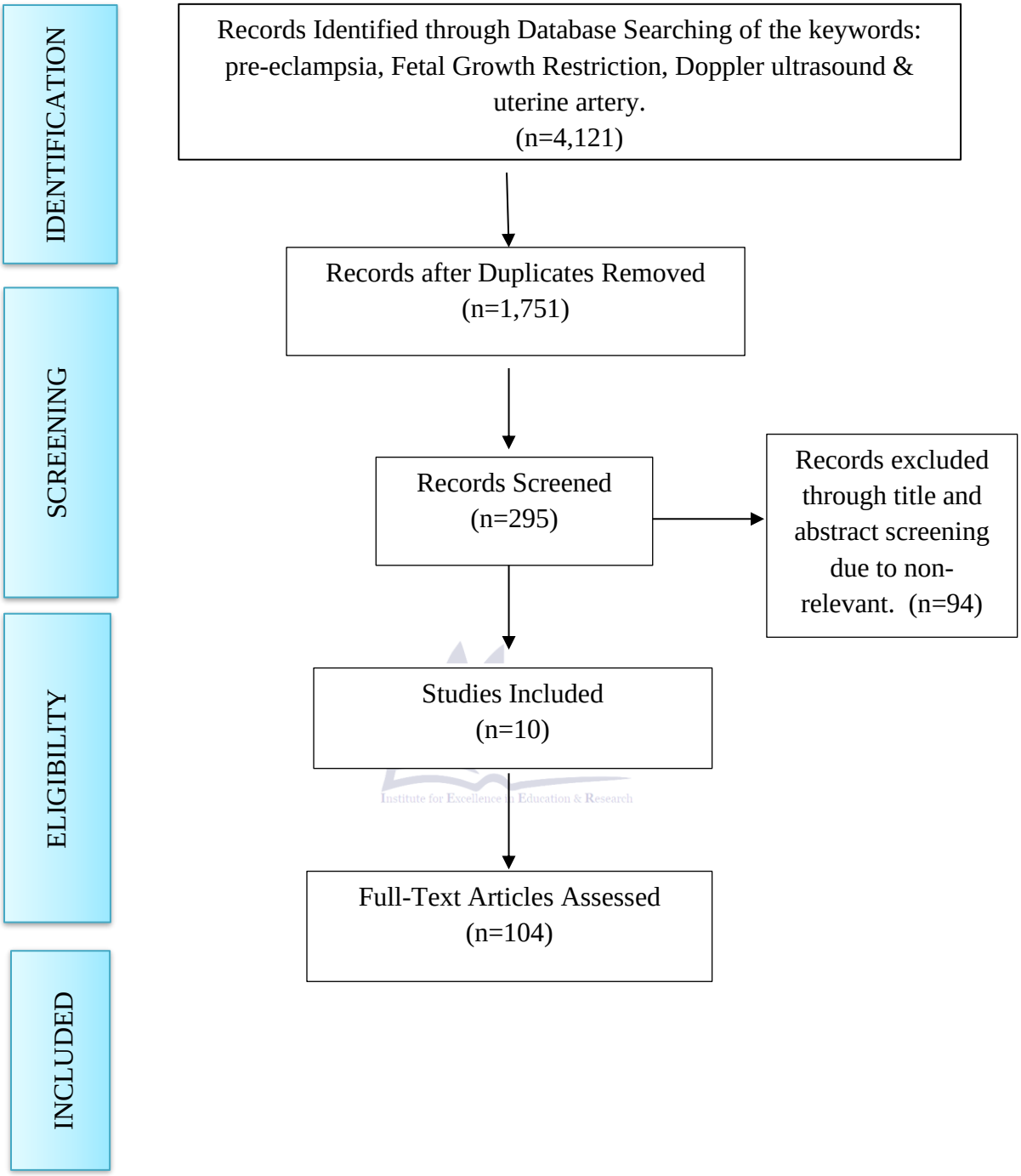


**Figure 1:** PRISMA flow diagram

**Table 1:** Key Findings of Different studies

| Authors | Year | Study Design | Sample size | Gestational week | Doppler parameter | | | Outcomes | Sensitivity % | Specificity % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RI | PI | Diastolic notching | | | |
| Ahmad Raza[6] | 2025 | Cross sectional Observational Study | 334 | 32-34 | 0.52±0.08 | N/A | N/A | IUGR 155(46.4%) | 76.7 | 87.3 |
| Sana Hafeez[7] | 2024 | Prospective observational study | 164 | 24 | N/A | N/A | Bilateral notch 80(48.7%) | IUGR 40(24.39%) | N/A | N/A |
| Deepak amnani[8] | 2023 | Prospective cohort study | 400 | 12-14 | N/A | 2.24 | N/A | PE 0(7.50%) | N/A | N/A |
| Praveen Kumar et al[9] | 2022 | Prospective observational study | 120 | 16-24 | >0.52 | >1.45 | N/A | PE 18 (15.83%) | For PE 83 | For PE 85 |
| | | | | | | | | IUGR 52(43.47%) | For IUGR 43 | For IUGR 97 |
| Jacqueline A Jayson[10] (14) | 2021 | Prospective cohort study | 270 | 11-14 | N/A | >1.5 | N/A | PE 28(10.29%) | 42.03 | 80.57 |
| | | | | | | | | IUGR 115 (42.64%) | | |
| Mariana et al[11] (15) | 2020 | Prospective observational study | 125 | 22-24 | N/A | N/A | Bilateral notch 9(7.2). | PE 1(11.3%) | For PE 72.7 | For PE 95.4 |
| | | | | | | | Unilateral Notch 23(18.4%) | IUGR 15(15.5%) | For IUGR 20 | For IUGR 89 |
| Ademola oseph[12] (16) | 2019 | Prospective cohort study | 98 | 22-24 | 0.59±0.13 | 1.38± 0.67 | N/A | PE 61(62.2%) | N/A | N/A |
| Seidighen Borna[13] (17) | 2018 | Prospective cohort study | 108 | 18-22 | N/A | >1.5 | Bilateral notch 13(12%) Unilateral notch 6(5.5%) | PE 28(25.92%) | N/A | N/A |
| | | | | | | | | IUGR 11(10.18%) | | |
| Eldeen Y Elkholi[14] (18) | 2016 | Prospective observational study | 266 | 12-14 | N/A | 2.66± 0.04 | Bilateral Notch 8(57.1%) | PE 14(5.26%) | For PE 45.8 | For PE 84.5 |
| | | | | | | 2.58± 0.04 | Bilateral notch 11(57.9%) | IUGR 19(7.14%) | For IUGR 47.36 | For IUGR 85.42 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A.T Papageorghios[15] (19) | 2001 | Cross sectional study | 7851 | 22-24 | N/A | >1.63 | Bilateral Notch 728(9.3%)<br><br>Unilateral Notch 875(11%) | PE with IUGR 42(0.5%) | PE with IUGR 69 | 95.2 |
| | | | | | | | | PE without IUGR 71(0.9%) | PE without IUGR 23 | 95.1 |
| | | | | | | | | IUGR without PE 698(8.9%) | IUGR without PE 13.2 | 95.7 |

PE: Pre-eclampsia, IUGR: intrauterine growth restriction, RI: Resistive index, PI: Pulsitility inde

## DISCUSSION

This systematic review sought to assess the predictive value of uterine artery Doppler ultrasound for pre-eclampsia (PE) and fetal growth restriction (FGR) using a variety of Doppler characteristics, including diastolic notching, pulsatility index (PI), and resistive index (RI). The majority of the included studies indicate the efficacy of uterine artery Doppler as a prediction technique, especially in the second trimester, and the results show sensitivity and specificity. A few criteria consistently demonstrated therapeutic relevance in the early identification of high-risk pregnancies, despite variations in sensitivity and specificity values among trials. In a cross-sectional observational study, Ahmad Raza evaluated 334 pregnant women between weeks 32 and 34 of pregnancy utilizing the resistive index (RI) on uterine artery Doppler ultrasound and record RI 0.52±0.08. According to the study, 46.4% of the patients had an intrauterine growth restriction (IUGR) diagnosis. The sensitivity of 76.7% and specificity of 87.3% for RI's diagnostic performance were determined to be clinically meaningful. Additionally, the study showed that RI is a valid measure for predicting IUGR in the third trimester, with a high positive predictive value of 87.1% and a negative predictive value of 77.1%[6]. In contrast to Ahmad Raza's findings, which demonstrated the efficacy of the resistive index (RI) in predicting IUGR, Sana Hafeez's study concentrated on diastolic notching as a Doppler parameter. With 164 pregnant women assessed at 24 weeks gestation, this prospective observational study reported a 24.39% incidence of IUGR with Bilateral notch 80(48.7%). Diastolic notching was significantly linked to IUGR, despite the study's lack of sensitivity or specificity data. In addition to the predictive significance shown by RI in later gestational weeks, these results imply that diastolic notching, when identified in the second trimester, may function as an early predictor of fetal growth restriction[7]. Another prospective cohort study conducted Deepak Ramnani evaluated the risk of pre-eclampsia (PE) in 400 women between 12 and 14 weeks of gestation by utilizing the pulsatility index (PI) and found PI 2.24. The study found a 7.5% incidence of PE, the early application of PI shows promise in PE screening during the first trimester[8].

In order to predict pre-eclampsia (PE) and intrauterine growth restriction (IUGR), Praveen Kumar et al. used RI, PI, and diastolic notching in a prospective observational study involving 120 pregnant women between 16 and 24 weeks of gestation. According to the study, there was a high incidence of PE (82.6%) and IUGR (43.47%). While the sensitivity and specificity for PE were 83% and 85%, respectively, the sensitivity and specificity for IUGR were 43% and 97%, respectively. These results imply that they have a strong potential as confirmatory instruments in clinical screening[9]. Prospective cohort research was carried out by Jacqueline A. Jayson with 270 women who were evaluated using the pulsatility index (PI) between weeks 11 and 14. The incidence of intrauterine growth restriction (IUGR) was 42.64% and pre-eclampsia (PE) was 10.29%, with PI>1.5 according to the study. With comparable results for IUGR prediction, PI showed strong specificity (80.57%) and intermediate sensitivity (42.03%) for PE prediction. These findings suggest that although PI may have low sensitivity, it is a valuable tool for excluding false positives in early screening due to its high specificity[10].

Mariana et al, used diastolic notching to conduct a prospective observational study on 127 women at 22–24 weeks. The study found that the incidence of intrauterine growth restriction (IUGR) was 15.5% and pre-eclampsia (PE) was 11.3% with bilateral notch 9(7.2%) and unilateral notch 23(18.4%). The diastolic notch demonstrated strong specificity (89%) and reasonable sensitivity (72.7%) for PE, but moderate sensitivity (20%) for IUGR. Mariana's results indicate that using diastolic notching alone may limit sensitivity, underscoring the benefit of multi-parameter assessment in enhancing diagnostic accuracy, in contrast to study conducted by Kumar et al. who employed a combination of RI, PI, and notching and achieved higher sensitivity for IUGR (43%) and similarly high specificity (97%)[11]. In a prospective cohort study by Ademola Joseph , 98 pregnant women were assessed between 22–24 weeks using RI and PI, found a notably high PE incidence of 62.2% with PI 1.38±0.67 and RI 0.59±0.13[12]. Another prospective cohort study on 108 women between 18 and 22 weeks of gestation by Seidighen Borna, who used diastolic notching and the pulsatility index (PI). A PE incidence of 25.92% and IUGR in

10.18% of patients were reported with PI >1.5 by the study. In comparison with Borna's study, PE was more common but IUGR was lower than Mariana et al, who evaluated women a little later at 22–24 weeks and found a PE incidence of 11.3% and IUGR in 15.5% of cases. Variations in clinical thresholds utilized for diagnosis, gestational age during screening, or population factors could all be responsible for this discrepancy[13].

In an effort to evaluate early predictors of adverse pregnancy outcomes Eldeen Y. Elkholi used PI and diastolic notching in a prospective observational study of 266 women at 12–14 weeks of gestation in an attempt to assess early markers of unfavorable pregnancy outcomes. According to the study, IUGR occurred in 7.14% with PI 2.58 of patients while PE occurred in 5.26% of cases with PI 2.66±0.04. For PE, the corresponding sensitivity and specificity were 45.8% and 84.5%, whereas for IUGR, they were 47.36% and 85.42%, respectively. These findings demonstrate the value of first-trimester Doppler screening in detecting low-risk pregnancies[14]. Using PI and diastolic notching, A.T. Papageorghiou evaluated PE and IUGR in a large-scale cross-sectional study with 7,851 participants between 22 and 24 weeks of gestation. PE with IUGR (0.5%) and PE without IUGR (0.9%) were found to be rare in the study, whereas IUGR without PE was more prevalent (8.9%) revealed PI >1.63. Specificity was generally high, especially for IUGR (95.7%), whereas sensitivity varied, ranging from 69% for PE with IUGR to only 13.2% for IUGR alone. In contrast to smaller studies such as those conducted by Eldeen Y. Elkholi and Jacqueline A. Jayson , which likewise showed high specificity but intermediate sensitivity, Papageorghiou's findings support the validity of uterine artery Doppler in excluding high-risk instances[15].

## CONCLUSION

Using measures such as diastolic notching, PI, and RI of uterine artery Doppler ultrasound has shown clinical utility in predicting fetal growth restriction (FGR) and pre-eclampsia (PE). Although the specificity of each Doppler index varies from study to study, its sensitivity is always high. In general, tests conducted in the second trimester produce higher predictive results than screens conducted earlier or later in pregnancy. Diagnostic accuracy is improved by combining many Doppler measures rather than relying solely on individual markers. Overall uterine artery Doppler is a useful non-invasive screening method for detecting high-risk pregnancies.

### Abbreviations

SFH= Syeda Faiza Hussaini
MZ= Muhammad Zubair
SK= Sara Kamal
MA= Muhammad Arif

## AUTHOR CONTRIBUTION

| Author | Contribution |
|---|---|
| Syeda Faiza Hussaini | Manuscript writing, Conceptualization, and methodology |
| Muhammad Zubair | Supervision, review of methodology, and editing of the final draft. |
| Sara Kamal | Data extraction, risk of bias assessment, data synthesis, and critical revision of the manuscript. |
| Muhammad Arif | Quality assessment, formatting, reference management, and proofreading |

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