ORIGINAL RESEARCH

Evaluating the Predictive Power of Second Trimester Uterine Artery Doppler for Preeclampsia and Fetal Growth Restriction: A Comprehensive Study

[1]Veeranki Leela Madhuri, [2]Nalappa Raju Suvidha, [3]K. Siva Naga Jyothi, [4]Srujana Goldie

[1,2,4]Assistant Professor, Department of Obstetrics & Gynaecology, Andhra Medical College, Visakhapatnam, India
[3]Senior Resident, Department of Obstetrics &Gynaecology, AIIMS, Mangalagiri, India

Corresponding Author
Srujana Goldie
Assistant Professor, Department of Obstetrics & Gynaecology, Andhra Medical College, Visakhapatnam, India

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ABSTRACT

Background: This study evaluates the utility of second-trimester uterine artery Doppler screening in predicting the risk of preeclampsia (PE) and fetal growth restriction (FGR) and examines its impact on pregnancy outcomes. **Methods:** A prospective cohort study was conducted involving 100 pregnant women in their second trimester were included, with specific criteria to target those at potential risk for PE and FGR. Uterine artery Doppler screening was performed to measure Pulsatility Index (PI) and Resistance Index (RI). Primary outcomes included the development of PE and FGR, with secondary outcomes assessing intervention effectiveness and neonatal outcomes. Statistical analyses included sensitivity, specificity, positive and negative predictive values, likelihood ratios, and Receiver Operating Characteristic (ROC) curve analysis. **Results:** Sensitivity for predicting PE was 85%, with a specificity of 48%, positive predictive value (PPV) of 40%, and negative predictive value (NPV) of 91%. For FGR, sensitivity was 71%, specificity was 45%, PPV was 23%, and NPV was 90%. Combined prediction sensitivity was 83%, specificity was 47%, PPV was 48%, and NPV was 86%. Statistical analysis showed significant relationships between Doppler screening and maternal/fetal outcomes ($p < 0.00001$ for maternal risk factors; $p = 0.001653$ for fetal outcomes). Among Doppler abnormalities, 36 cases developed hypertensive disorders of pregnancy despite prophylactic aspirin administration. **Conclusion:** Second-trimester uterine artery Doppler screening demonstrates promising predictive accuracy for PE and FGR. Despite limitations, early detection offers opportunities for intervention in high-risk pregnancies, potentially improving maternal and fetal outcomes. **Recommendations:** Implementing routine second-trimester uterine artery Doppler screening in clinical practice may enhance risk stratification for PE and FGR, guiding timely interventions to mitigate adverse pregnancy outcomes.

Keywords: Uterine Artery Doppler, Preeclampsia, Fetal Growth Restriction, Predictive Accuracy.

INTRODUCTION

Evaluating the predictive power of second trimester uterine artery Doppler for preeclampsia and fetal growth restriction is of paramount importance in obstetrics. Preeclampsia is a complex condition marked by hypertension and often proteinuria after the 20th week of pregnancy, impacting both maternal and fetal health. Fetal growth restriction (FGR) refers to a fetus not achieving its genetically determined potential size, with significant implications for neonatal and long-term health. The early detection and management of these conditions are crucial for improving clinical outcomes [1].

The use of second trimester uterine artery Doppler ultrasonography offers a non-invasive method to assess the risk of developing preeclampsia and FGR. This technique measures the blood flow in the uterine arteries, where abnormal patterns, such as increased resistance or notching, can indicate impaired placentation—a common factor underlying both preeclampsia and FGR [2]. The strength of uterine artery Doppler lies in its ability to identify high-risk pregnancies early, thereby enabling targeted interventions.

Research has consistently shown that abnormal findings from uterine artery Doppler assessments in the second trimester significantly correlate with an

increased risk of preeclampsia and FGR. Bujold et al. [3] highlighted that bilateral uterine artery notching is particularly predictive of early-onset preeclampsia and severe FGR. Moreover, combining uterine artery Doppler results with other markers, including maternal history, biophysical parameters, and biochemical markers (e.g., PlGF and PAPP-A), enhances screening accuracy [4].

Despite its potential benefits, the integration of uterine artery Doppler screening into routine prenatal care faces challenges. Variations in screening methodologies, interpretation of results, and subsequent management strategies must be addressed to optimize its clinical utility. Consensus on these issues, alongside improvements in healthcare infrastructure, is necessary for widespread adoption [5].

The predictive power of second trimester uterine artery Doppler for preeclampsia and FGR is well-documented. Future research should aim at optimizing screening protocols and developing effective management strategies for identified high-risk cases, with the goal of enhancing maternal and fetal health outcomes.

The aim of the study is to evaluate the usefulness of second trimester uterine artery Doppler screening in predicting the risk of preeclampsia, to determine the sensitivity and specificity of uterine artery Doppler indices in predicting preeclampsia (PE) and fetal growth restriction (FGR), and to determine the outcome of pregnancy.

METHODOLOGY

Study Design

This research employs a prospective cohort study design.

Study Setting

The study is conducted at Government tertiary care hospital, spanning from September 2022 to August 2023.

Participants

The study included 100 cases targeting pregnant women in their second trimester. This timing is chosen because it allows for early detection of potential complications, offering a window for interventions that could improve pregnancy outcomes.

Inclusion Criteria

The inclusion criteria are specifically designed to select a population at potential risk for PE and FGR with or without a history of these conditions. Eligible participants are those in the 22nd to 24th week of gestation, with or without previous pregnancies affected by preeclampsia or chronic hypertension.

Exclusion Criteria

Excluded from the study are women with pre-existing medical conditions that could affect pregnancy outcomes (such as diabetes or renal disease), and women with anomalous foetuses. These criteria ensure that the study focuses on the predictive value of Doppler screening in a relatively low-risk population.

Bias

There was a chance that bias would arise when the study first started, but it was avoided by giving all participants the identical information and hiding the group allocation from the nurses who collected the data.

Variables

Variables included demographic details, clinical symptoms, laboratory parameters, and outcomes.

Data Collection

Data are collected through a combination of patient interviews and reviews of medical records. Information gathered includes demographic data (such as age and BMI), obstetric history, and detailed pregnancy outcomes. This approach ensures the collection of both qualitative and quantitative data necessary for a thorough analysis.

Uterine Artery Doppler Screening

Screening involves the use of ultrasound Doppler to measure the Pulsatility Index (PI) and Resistance Index (RI) of the uterine arteries. These indices are critical in assessing the blood flow and resistance within the uterine arteries, which can indicate the likelihood of PE and FGR.

Outcome Measures

Primary outcomes include the development of preeclampsia and fetal growth restriction. Secondary outcomes measure the effectiveness of early intervention, including gestational age at delivery, birth weight, and the need for neonatal ICU admission. These outcomes provide a comprehensive overview of the impact of uterine artery Doppler screening on maternal and fetal health.

Statistical Analysis

The study employs a range of statistical analyses to assess the predictive value of uterine artery Doppler indices. Sensitivity, specificity, positive and negative predictive values, and likelihood ratios are calculated to determine the effectiveness of PI and RI measurements in predicting PE and FGR. Receiver Operating Characteristic (ROC) curve analysis is used to identify the optimal cutoff values for these indices, enhancing the screening process's predictive accuracy.

Ethical considerations

The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

RESULT

The study included 100 cases and the results of the study on the predictive accuracy of second-trimester uterine artery Doppler screening for PE and FGR revealed insightful findings. The sensitivity of the Doppler screening in predicting PE was found to be 85%, indicating a high ability to correctly identify actual PE cases. The specificity was recorded at 48%, which reflects the screening's precision in recognizing pregnancies not affected by PE. The positive predictive value (PPV) stood at 40%, showing the probability that pregnancies identified as at-risk by the screening indeed develop PE, while the negative predictive value (NPV) was notably high at 91%, indicating a strong likelihood that pregnancies not flagged as at-risk do not develop PE.

Table 1: Demographics of study population

Parameters	Percentage
Age (years)	
- 18-22	70%
- 23-27	22%
- 28-35	6%
- >35	2%
Parity distribution	
- PRIMI	54%
- G2	35%
- G3	7%
- G4	3%
- G5	1%
Doppler abnormality	
- Normal	44%
- Abnormal	56%
Complications during previous pregnancy	
- GHTN	12%
- Preeclampsia	10%
- Chronic HTN	7%
- Abruption	4%
- IUD/Still birth	4%
- BOH	3%
- FGR/Small for GA	6%

In terms of predicting FGR, the study showed a sensitivity of 71%, denoting a robust capacity to correctly identify actual cases of FGR. The specificity for FGR prediction was 45%, indicating the accuracy of the screening in identifying pregnancies without FGR. The PPV for FGR was 23%, which points to the likelihood that pregnancies deemed at-risk actually experience FGR, and the NPV was 90%, reflecting a high probability that pregnancies not identified as at-risk remain free of FGR.

When considering the combined prediction of PE and FGR, the sensitivity was found to be 83%, underscoring the Doppler screening's overall effectiveness in correctly identifying either condition. The specificity for the combined conditions was 47%, indicating the screening's ability to accurately rule out both conditions when they are not present. The PPV for the combined prediction was 48%, suggesting a moderate likelihood that positive screenings accurately indicate the presence of either PE or FGR, while the NPV was 86%, showcasing a strong probability that negative screenings accurately predict the absence of both conditions.

Statistical analysis supported the significance of the Doppler study in the early detection of pregnancy-related risks, with a chi-square statistic of 21.2557 and a p-value < 0.00001 for predicting maternal risk factors, demonstrating a statistically significant relationship. For fetal outcomes, the chi-square statistic was 9.9 with a p-value of 0.001653, also indicating statistical significance.

Among the 100 cases studied, 56 exhibited abnormalities in Doppler screening. Notably, 36 of these cases developed hypertensive disorders of pregnancy (HDP) highlighting the potential for early intervention in high-risk pregnancies.

DISCUSSION

The study's results demonstrate the significant predictive value of second-trimester uterine artery Doppler screening in identifying the risk of preeclampsia and fetal growth restriction. With a high sensitivity for both conditions (85% for PE and 71% for FGR), the screening effectively identifies most at-risk pregnancies.

However, the modest specificity (48% for PE and 45% for FGR) suggests that the screening may also flag some pregnancies as at-risk when they are not, highlighting a trade-off between identifying as many true cases as possible and the risk of false positives.

The high negative predictive values (91% for PE and 90% for FGR) are particularly reassuring, indicating that pregnancies deemed not at-risk by the screening are very likely to proceed without these complications.

The results affirm the utility of Doppler screening as a tool for early intervention in high-risk pregnancies, despite the need for careful interpretation of positive results to manage false positives effectively. The significant statistical findings further reinforce the screening's role in enhancing prenatal care by facilitating timely and targeted interventions for improving maternal and fetal health outcomes.

Several studies have explored the prediction and outcomes of Fetal Growth Restriction (FGR) with notable findings. The evaluation of different fetal Doppler indices highlighted the sensitivity of umbilical artery Doppler and specificity of MCA in predicting adverse perinatal outcomes, underscoring the importance of Doppler screenings in managing FGR [6]. Another study emphasized the significant role of placental growth factor levels in the first trimester as a predictor for maternal and perinatal adverse outcomes, particularly in preeclampsia and FGR cases, indicating a potential early biomarker for these conditions [7].

Additionally, research assessing the impact of uterine artery Doppler suggested that normal UAPI readings in low-risk women do not rule out the development of PIH and FGR, pointing to the need for further investigation into routine UAPI use [8]. The association of D-dimer and lipid biomarkers with preeclampsia also highlighted the potential of early screening to significantly reduce morbidity and mortality [9]. Furthermore, the cerebro-placental ratio's prognostic value in high-risk pregnancies with intrauterine growth restriction was emphasized, suggesting its significance in predicting perinatal outcomes [10]. These studies collectively contribute to the understanding and management of FGR, offering insights into early prediction, biomarkers, and the potential for intervention in high-risk pregnancies.

CONCLUSION

In conclusion, the study demonstrates the potential utility of second-trimester uterine artery Doppler screening in predicting the risk of PE and FGR among pregnant women. Despite moderate specificity and positive predictive value, the high sensitivity and negative predictive value suggest its effectiveness in identifying at-risk pregnancies and excluding those not at risk. The statistical analyses underscore the significance of Doppler screening in predicting maternal risk factors and fetal outcomes, highlighting its potential clinical relevance. Challenges remain in preventing hypertensive disorders of pregnancy (HDP) despite prophylactic measures. Integrating Doppler screening into routine prenatal care protocols may facilitate risk stratification and improve maternal-fetal health outcomes, but further research is needed to refine its predictive accuracy and evaluate its impact on clinical decision-making.

Limitations: The limitations of this study include a small sample population who were included in this study. The findings of this study cannot be generalized for a larger sample population. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

Recommendation: Implementing routine second-trimester uterine artery Doppler screening in clinical practice may enhance risk stratification for PE and FGR, guiding timely interventions to mitigate adverse pregnancy outcomes.

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List of Abbreviations

1. PE - Preeclampsia
2. FGR - Fetal Growth Restriction
3. RI - Resistance Index
4. PI - Pulsatility Index
5. ICU - Intensive Care Unit
6. BMI - Body Mass Index
7. PlGF - Placental Growth Factor
8. PAPP-A - Pregnancy-Associated Plasma Protein-A
9. HTN - Hypertension
10. GHTN - Gestational Hypertension
11. BOH - Bleeding on Hypertensive Disorder
12. IUD - Intrauterine Death
13. PRIMI - Primigravida
14. ROC - Receiver Operating Characteristic
15. NPV - Negative Predictive Value
16. PPV - Positive Predictive Value
17. UAPI - Uterine Artery Pulsatility Index
18. MCA - Middle Cerebral Artery
19. PIH - Pregnancy-Induced Hypertension
20. HDP - Hypertensive Disorders of Pregnancy

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