

Exploring the Efficacy of Doppler Studies in Detecting Pregnancy-Induced Hypertension (PIH) and Intrauterine Growth Restriction (IUGR) in First-Time Mothers

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Abstract

Background: The right of every newborn to be born undamaged, both mentally and physically, underscores the significance of maternal-fetal medicine, primarily aimed at ensuring safe pregnancy outcomes. Pregnancy-induced hypertension remains a critical challenge, especially in developing countries, where it complicates approximately 7 to 15 percent of pregnancies and is the second leading cause of maternal mortality.

Aim: To explore the efficacy of Doppler studies in detecting 'pregnancy-induced hypertension' (PIH) and 'intrauterine growth restriction' (IUGR) in primigravida (first-time mothers) by evaluating the correlation between Doppler parameters and maternal-fetal outcomes.

Methodology: This study was conducted over six months at Narayan Medical College and Hospital, Sasaram, Bihar, India the prospective study involved 70 women beyond 34 weeks of gestation with diagnosed PIH. Participants underwent detailed obstetric examinations and Doppler ultrasonography of the umbilical artery to assess blood flow dynamics, with follow-up until delivery to classify newborns based on growth parameters.

Results: An even distribution of participants was noted between low-risk and high-risk categories (35 patients each). Key findings indicated that a prior history of hypertensive disorders was prevalent in 48.57% of high-risk patients. Notably, abnormal Pulsatility Index (PI) was linked to a significant increase in hypertension progression in both low-risk (50%) and high-risk (66.66%) groups, with a P-value of 0.000 underscoring this correlation. Doppler ultrasonography exhibited high specificity and moderate sensitivity in identifying preeclampsia, particularly beneficial for high-risk groups.

Conclusion: The integration of Doppler ultrasonography improves the management of high-risk pregnancies complicated by PIH and IUGR. Abnormal PI serves as a critical indicator for hypertension, necessitating individualized care strategies. The study advocates for continued exploration of innovative antenatal care methods, particularly in resource-limited settings, to enhance maternal and neonatal health outcomes.

Keywords: Antenatal Care, Doppler Ultrasonography, Intrauterine Growth Restriction, Maternal-Fetal Medicine, Pregnancy-Induced Hypertension, Partogram.

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Introduction

The right to an unharmed bodily and mental birth is guaranteed to every newborn. The achievement of this purpose is crucial in materno-fetal medicine, which aims to provide a healthy result for both the mother and the infant in every pregnancy [1]. The majority of gestation, labors, and births are typical biological processes that provide favorable outcomes for both mother and child; but, atypical cases may lead to maternal and perinatal morbidity or significant death. The primary objective of

prenatal care is to identify gestations at risk for problems and to address them promptly. Pregnancy-induced hypertension is a prominent and complex unresolved issue in obstetrics, posing a considerable challenge to obstetricians, especially in underdeveloped nations. This indicates the presence of an underlying disease that may arise during pregnancy or may not be present at all. They are only surpassed in underdeveloped nations by anemia,

which complicates between 7 and 15 percent of pregnancies.

This is the second leading cause of maternal death globally. Pre-eclampsia often occurs in first-trimester pregnancies and is believed to arise from insufficient trophoblast invasion of the maternal spiral arteries. This prevalent disorder restricts the availability of substrates essential for fetal growth also development, leading to intrauterine growth restriction and presenting as a birth weight below the 10th percentile for gestational age.

The trophoblast initiates invasion of the decidual segment of the spiral arteries by the eighth week, often concluding by the twelfth week. Then, the second phase of spiral artery invasion starts, when the myometrial section of the spiral arteries is penetrated. This is typically completed by 18 to 19 weeks. This process results in the formation of a vascular bed characterized by low resistance, low pressure, and rapid blood flow [5]. Physiological alterations during pregnancy convert the spiral arteries from tiny muscle arteries into dilated, convoluted, also 'funnel-shaped uteroplacental vessels, enabling them to accommodate the hemodynamic stresses of pregnancy.' The alteration of the spiral artery bed primarily does not transpire in individuals with pre-eclampsia owing to the inadequate progression of the second phase of endovascular trophoblast migration, resulting in increased resistance to flow into the intervillous space and a reduced blood supply to the fetoplacental unit. This process develops a vascular bed characterized by low resistance, low pressure, also rapid blood flow.

Physiological alterations during gestation convert the spiral arteries from diminutive muscle arteries into enlarged, convoluted, also funnel-shaped uteroplacental vessels, enabling them to withstand the hemodynamic pressures of gestation. Brain development is spared in the early stages, although fetal length is compromised. However, if the damage persists, cerebral development is also hindered. Initially, the Systolic-Diastolic ratio of the Umbilical Artery increases while the Systolic-Diastolic ratio of the Middle Cerebral Artery decreases, signifying placental resistance. This is subsequently followed by a reduced MCA Systolic-Diastolic ratio compared to the 'UA Systolic-Diastolic ratio, indicating centralization of flow.

The Doppler assessment of the Umbilical Artery indicates missing and reversed flow, correlating with negative perinatal outcomes. Direct evaluation of trophoblastic invasion during human gestation is unfeasible; however, the advent of Doppler ultrasonography has enabled the measurement of 'uteroplacental and fetoplacental blood flow, as well as fetal blood circulation'. The uteroplacental also fetoplacental circulations provide insights into

placental resistance, while the evaluation of 'fetal circulation can non-invasively measure the fetal response to hypoxia' [6]. The objective of this study was to investigate the efficacy of Doppler studies in detecting pregnancy-induced hypertension and intrauterine growth restriction in first-time mothers.

Methodology

Study Design

This prospective study was conducted over a period of six months in the Department of Obstetrics and Gynaecology, Narayan Medical College and Hospital, Jamuhar, Sasaram, Bihar, India. The objective of the study was to assess the efficacy of Doppler studies in detecting PIH and IUGR in first-time mothers.

Sample Size

The study involved a total of 70 pregnant women with singleton pregnancies complicated by pregnancy-induced hypertension and a clinical suspicion of intrauterine growth restriction.

Inclusion and Exclusion Criteria

Inclusion criteria for the study required pregnant women beyond 34 weeks of gestation with singleton pregnancies that were complicated by PIH and had a clinical suspicion of IUGR. Gestational age was determined based on the last menstrual period.

Exclusion criteria

Gestational diabetes

Multifoetal pregnancies

Pregnant women who did not attend follow-up

Chronic illnesses

Women with uncertain LMP

Procedure

The study included a comprehensive obstetric evaluation of all participants, succeeded by umbilical artery Doppler ultrasonography employing a 3.5 MHz curvilinear probe on a GE Medical LOGIQ P3 systems. Doppler measurements were performed subsequent to acquiring a comprehensive patient history. The systolic to diastolic ratio was determined using a free segment of the umbilical cord situated halfway between the placenta and the cord insertion point. Measurements were conducted during fetal quiescence and apnea to guarantee precision. Participants were monitored till delivery. At delivery, the weights of the babies were documented, and they were categorized as either Small for Gestational Age or Appropriate for Gestational Age according to the Lubchenco chart. SGA babies were classified as having intrauterine growth restriction (IUGR). Fetal outcomes were classified as either normal or unfavorable, with poor

outcomes encompassing prenatal hypoxia, periventricular leukomalacia, intraventricular hemorrhage, and newborn mortality.

Statistical Analysis:

The statistical analysis was conducted using SPSS software, specifically version 27. The results were interpreted to assess the effectiveness of the partogram in managing labor. The Chi-square test was used to analyze categorical data. The P-value below 0.05 was indicated the statistical significance of result.

Result

Table 1 displays the distribution of patients classified by their risk levels, indicating an equal division between the two categories. Each the low-risk and high-risk category consists of 35 individuals, accounting for 50% of the total patient population in both groups. This signifies a proportional representation of risk levels among the evaluated patients.

Table 1: Distribution of patients by risk category

Risk Group	Low Risk	High Risk
No. of Patients	35	35
%	50%	50%

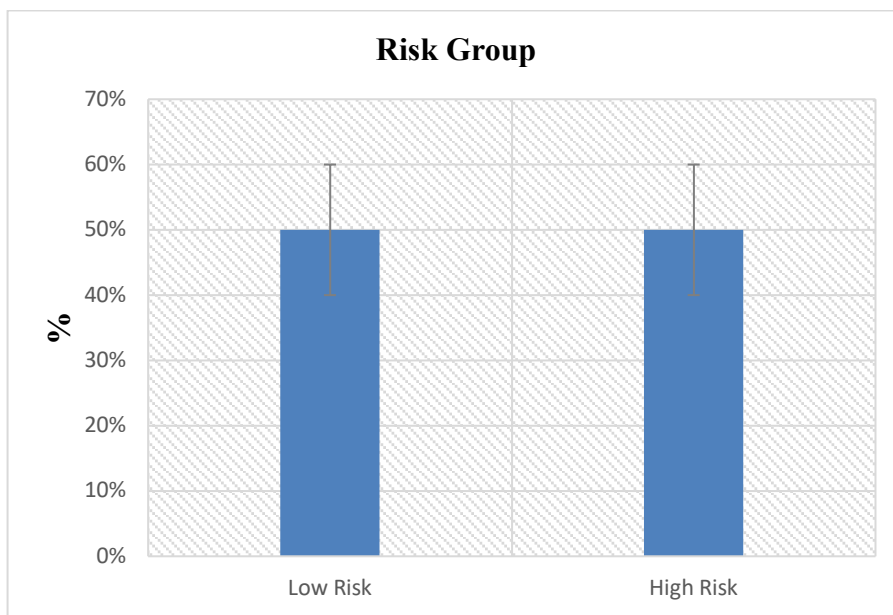


Figure 1: Distribution of patients by risk category

Table 2 shows the distribution of high-risk individuals classified by distinct risk variables. The predominant risk factor was a prior history of hypertensive disorders of pregnancy (HDP), impacting 34 individuals, or 48.57% of the overall population. A history of intrauterine growth restriction (IUGR) was observed in 18 patients

(25.71%), whereas 6 patients (8.57%) had a history of stillbirth in prior pregnancies. Additional risks encompassed advanced maternal age (over 35 years), obesity, and diabetes mellitus, each impacting 2 patients (2.86%), along with a history of preterm birth, which impacted 6 patients (8.57%).

Table 2: Distribution of high-risk category by risk factors

Risk factor	No. of patients	%
Previous history of HDP	34	48.57%
Previous history of IUGR	18	25.71%
H/O stillbirth in previous pregnancy	6	8.57%
Age > 35	2	2.86%
Obesity	2	2.86%
Diabetes mellitus	2	2.86%
H/O preterm delivery	6	8.57%

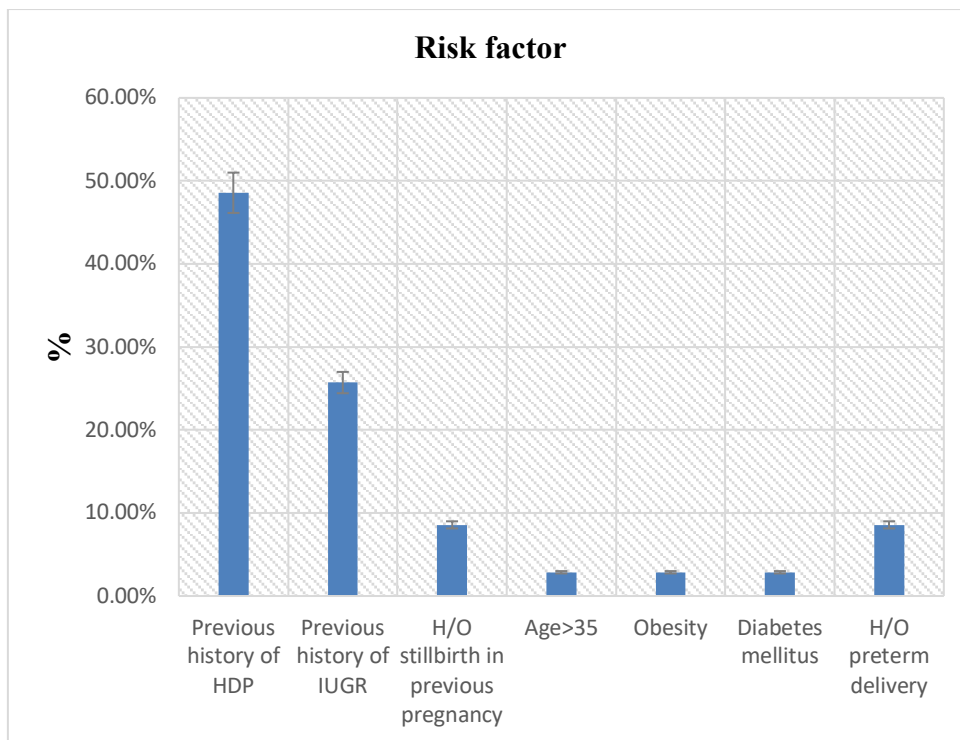


Figure 2: Distribution of high-risk category by risk factors

Table 3 provides data about the progression of hypertension within a low-risk cohort classified by Pulsatility Index (PI). Of the 10 patients with an abnormal PI (≥ 10), 50% developed hypertension, while only 3.33% of the 60 patients with a normal PI (≤ 60) suffered hypertension. A P-value of 0.000

signifies a statistically significant correlation among aberrant PI also the occurrence of hypertension, indicating that individuals with an abnormal PI have a substantially elevated risk of acquiring hypertension relative to those with a normal PI.

Table 3: Hypertension development concerning aberrant PI in the low-risk cohort

Pulsatility Index (PI)	Abnormal (10)	Normal (60)
No. of Patients	10	60
Hypertension (%)	5 (50.0%)	2 (3.33%)
No Hypertension (%)	5 (50.0%)	58 (96.67%)
P-Value	0.000	

Table 4 provides statistics about the progression of hypertension within a high-risk cohort, as determined by the Pulsatility Index (PI). Six of the nine individuals (66.66%) who had an abnormal PI went on to develop hypertension, whereas the remaining three (33.34%) did not. However, among the 61 patients with a normal PI, only 3.28% (2 patients) developed hypertension, whilst a

significant 96.72% (59 patients) maintained normotension. A P-value of 0.000 signifies a statistically significant disparity in hypertension prevalence between individuals with abnormal and normal PI, indicating a robust association between aberrant PI and an elevated risk of hypertension in this high-risk cohort.

Table 4: Development of hypertension in the high-risk group in relation to aberrant PI

Pulsatility Index (PI)	Abnormal (9)	Normal (61)
No. of patients	9	61
Hypertension (%)	6 (66.66%)	2 (3.28%)
No Hypertension (%)	3 (33.34%)	59 (96.72%)
P-value	0.000	

Table 5 displays the predictive efficacy of Doppler ultrasonography in identifying preeclampsia across various risk categories. The low-risk group's

specificity is high at 93.5%, demonstrating a great ability to identify individuals without the ailment, while the sensitivity is 55%, suggesting a moderate

capacity to accurately identify those with the illness. ‘This has a positive predictive value of 78% also a negative predictive value of 89.2%’. The high-risk group has a sensitivity of 70% also a slightly reduced specificity of 92.3%. This cohort has a positive predictive value of 80% and a negative predictive

value of 90.5%. Doppler ultrasonography exhibits commendable specificity in both groups; however, its sensitivity is significantly elevated in the high-risk group, indicating superior predictive usefulness for individuals at heightened risk of preeclampsia.

Table 5: Doppler's predictive value for preeclampsia in risk groups

Risk Group	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Low Risk	55	93.5	78	89.2
High Risk	70	92.3	80	90.5

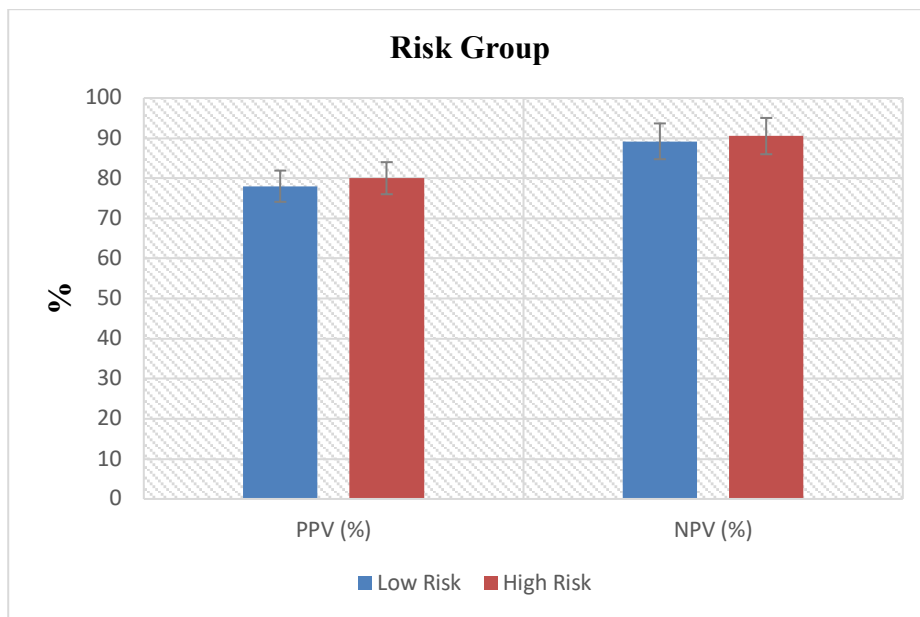


Figure 5: Doppler's predictive value for preeclampsia in risk groups

Discussion

The patient population was evenly split between low-risk and high-risk categories, with each group comprising 35 individuals, accounting for 50% of the total. This equal representation provides a solid foundation for comparing the outcomes and risk factors associated with hypertension across different profiles. Kearney et al. (2005) conducted an extensive investigation of the worldwide burden of hypertension, published in The Lancet [7]. This study demonstrated that the prevalence of hypertension greatly differs among communities, with notable outcomes identified between low-risk and high-risk groups. The authors underscored the necessity of stratifying patients according to their risk profiles, so reinforcing the notion that equitable representation in research, as exemplified by the specified patient group, establishes a solid foundation for outcome comparison. The results emphasize the need for customized management techniques according to risk classification. A research by Muntner, Shimbo, and Arnett (2013), published in the American Journal of Hypertension, emphasized the essential need of precise blood

pressure monitoring in hypertension therapy [8]. Patients categorized into distinct risk classifications, such as low-risk and high-risk, have divergent outcomes and treatment responses. This underscores the importance of examining equally divided populations, as it facilitates a more nuanced comprehension of the impact of risk variables on hypertension therapy and patient outcomes.

The distribution of high-risk individuals based on specific risk factors reveals that a prior history of hypertensive disorders of pregnancy (HDP) was the most prevalent factor, affecting 34 patients, or 48.57%. This suggests that previous hypertensive conditions are a significant contributor to the current risk of developing hypertension. Additionally, a history of intrauterine growth restriction (IUGR) was noted in 18 patients (25.71%), indicating another critical risk factor. The presence of multiple risk factors, such as advanced maternal age, obesity, and diabetes mellitus, although affecting fewer patients, underscores the complexity of patient histories that may contribute to hypertension risk. ‘The age of our patients varied from 20 to 30 years, with a mean age of 25.2±2.6 years, consistent with

the findings of Jasovic-Siveska E et al. [9]. The mean age of the female participants in our study was 25.36 ± 3.46 years. Women having a mean gestational age of 31.58 ± 1.68 weeks, ranging from 27.4 to 34 weeks, were included in this study. The mean gestational ages at admission in the studies by Edward et al., Robertson et al., and Smolin et al. were 28.5, 27.8, and 30.8 weeks, respectively [10, 11, 12].

The correlation between Pulsatility Index (PI) and hypertension progression within the low-risk cohort. The data indicate that 50% of patients with an abnormal PI (≥ 10) developed hypertension, compared to just 3.33% in the normal PI group (≤ 60). The statistically significant P-value of 0.000 underscores the strong association between abnormal PI and increased hypertension risk, indicating that even patients classified as low-risk can have significant underlying vulnerabilities. The high-risk cohort's progression of hypertension relative to PI levels. Here, 66.66% of patients with an abnormal PI developed hypertension, a substantial increase compared to only 3.28% of those with normal PI. Again, the P-value of 0.000 reinforces the strong association between abnormal PI and hypertension risk, emphasizing the critical need for monitoring PI in high-risk patients to identify those requiring closer management. Zhang et al. (2019) conducted a population-based study entitled 'Elevated Pulsatility Index is Associated with the Progression of Hypertension,' published in Hypertension Research [13]. This study highlights the relationship between increased PI and the advancement of hypertension, especially in low-risk populations. The authors assert that an aberrant PI may indicate a risk of underlying hypertension, emphasizing the necessity for careful monitoring of individuals deemed low-risk.

The efficacy of Doppler ultrasonography in predicting preeclampsia across the two risk categories. The low-risk group exhibited high specificity (93.5%), suggesting it effectively rules out those without the disease; however, the sensitivity (55%) indicates that many cases of preeclampsia may go undetected in this group. Conversely, the high-risk group demonstrated improved sensitivity (70%) and slightly lower specificity (92.3%), indicating a better capacity for identifying cases of preeclampsia among those already at heightened risk. The positive predictive value and negative predictive value for both groups further highlight the potential of Doppler ultrasonography as a useful clinical tool, particularly for high-risk individuals. Brennan et al. (2021) focused on assessing the predictive values of Doppler ultrasonography across several risk categories [14]. Their research shown that Doppler ultrasonography has significant positive and negative predictive values, especially in high-risk

groups. The collected data underscored the method's efficacy in clinical practice, equipping healthcare practitioners with a reliable technique of identifying pregnancies at risk for preeclampsia development.

Conclusion

This study highlights the importance of effective antenatal care in managing pregnancies complicated by pregnancy-induced hypertension and intrauterine growth restriction. The integration of Doppler ultrasonography significantly enhances the identification of high-risk pregnancies, with a notable correlation between abnormal Pulsatility Index (PI) and hypertension development, even in low-risk patients. The findings emphasize that a history of hypertensive disorders substantially influences risk profiles, necessitating tailored management strategies. Additionally, Doppler ultrasonography proves to be a valuable tool for predicting preeclampsia, particularly in high-risk patients. Future research should focus on innovative approaches to antenatal care, particularly in resource-limited settings, to mitigate risks associated with hypertensive disorders and enhance maternal and perinatal health outcomes.

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