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ORIGINAL ARTICLE

Comparing Doppler indices of umbilical artery in pregnancy-induced hypertension and normal pregnant women during the third trimester of pregnancy.

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ABSTRACT… Objective: To compare Doppler indices of umbilical artery - resistance index (RI), pulsatility index (PI), and systolic to diastolic (SD) ratio between pregnancies complicated by pregnancy induced hypertension (PIH) and normotensive pregnancies in the third trimester. **Study Design:** Comparative Cross-Sectional Study. **Setting:** Aziz Fatimah Hospital, Faisalabad, Pakistan. **Period:** June 2024 to December 2024. **Methods:** In this study, 100 singleton pregnancies (50 PIH, 50 normotensive) underwent ultrasound Doppler assessment at 32-38 weeks' gestation. Mean PI, RI, and S/D ratio were calculated for each group. Independent t-test and Mann-Whitney U test were applied, with significance at $p < 0.05$. **Results:** All Doppler indices were significantly higher in the PIH group (PI 1.26 ± 0.25; RI 0.72 ± 0.06; S/D 4.08 ± 0.58) than in normotensive controls (PI 0.81 ± 0.13; RI 0.55 ± 0.06; S/D 2.08 ± 0.27) ($p < 0.001$ for each). Elevated indices indicate increased placental vascular resistance consistent with impaired fetoplacental perfusion. **Conclusion:** Pregnancy-induced hypertension is associated with significantly raised umbilical-artery PI, RI, and S/D ratio, corroborating previous evidence of placental insufficiency in hypertensive pregnancies. Routine third-trimester Doppler surveillance and serial monitoring of these indices may facilitate early intervention and improve perinatal outcomes.

Key words: Pregnancy Induced Hypertension, Pulsatility Index, Placental Insufficiency, Resistive Index, Spectral Doppler, Umbilical Artery.

INTRODUCTION

Pregnancy-induced hypertension (PIH) is one of the most common and potentially serious complications affecting maternal and fetal health, particularly in the second half of pregnancy. It is characterized by elevated blood pressure after 20 weeks of gestation in women with no prior history of hypertension.[1] As one of the most prevalent hypertensive disorders of pregnancy, PIH can lead to severe maternal and fetal complications if not identified and managed promptly. It remains a leading cause of adverse perinatal outcomes globally and continues to be a major contributor to maternal mortality.[2] The impact is especially pronounced in low- and middle-income countries, where limited access to early diagnosis and specialized antenatal care often results in delayed interventions. Globally, hypertensive disorders in pregnancy are estimated to affect approximately 5–10% of all pregnancies.[3]

The clinical consequences of PIH are far-reaching. In mothers, it can lead to multi-organ dysfunction, including renal impairment, hepatic complications, and neurological symptoms, and may progress to life-threatening conditions such as eclampsia or HELLP syndrome.[4] In fetuses, PIH is closely associated with intrauterine growth restriction (IUGR), Oligohydramnios, low birth weight, preterm birth, and even intrauterine fetal demise.[5] Hence, there is a critical need for monitoring tools that can assess fetal well-being and guide clinical decision-making in pregnancies complicated by PIH.[6]

Doppler ultrasound is a non-invasive technique in modern obstetric practice, especially for the management of high-risk pregnancies.[7]

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Among the various fetal vessels assessed, the umbilical artery plays a pivotal role in evaluating placental resistance and fetoplacental circulation.[8] Through Doppler analysis of this artery, clinicians can obtain essential hemodynamic indices that reflect the degree of blood flow resistance between the fetus and the placenta. Abnormal values in these indices suggest impaired placental function and are often observed in pregnancies affected by PIH and preeclampsia. These Doppler findings are especially valuable between 28 and 34 weeks of gestation, when fetal growth accelerates and metabolic demands increase, making the fetus more susceptible to placental insufficiency.[9]

While developed countries have widely implemented umbilical artery Doppler studies for the early detection of fetal compromise in pregnancies with PIH, their routine use remains limited in Pakistan. International studies have established Doppler ultrasound as a standard surveillance tool, but in Pakistan, local data remains scarce, and population-specific reference values are lacking. This research gap impairs clinical decision-making and affects fetal outcomes in hypertensive pregnancies. Therefore, this study was conducted to evaluate Doppler indices in Pakistani women with PIH, aiming to contribute vital baseline data that can enhance fetal assessment and strengthen antenatal care in our healthcare setting.

METHODS

This comparative cross-sectional study was carried out at Aziz Fatimah Hospital, Faisalabad, from June 2024 to December 2024, after obtaining ethical approval from the Research Committee of Aziz Fatimah Medical and Dental College (IEC/289-24). Data collection spanned from June 2024 to December 2024. The sample size was calculated through open epi. A total of 100 pregnant women aged from 20 to 40 years with a gestational age beyond 28 weeks, were enrolled. The participants were divided into equal two groups: 50 women with clinically suspected pregnancy-induced hypertension (PIH) and 50 normotensive pregnant women. Women with multiple gestations, fetal anomalies, gestational age less than 28 weeks, chronic hypertension, diabetes mellitus (both pre-gestational and gestational), renal disease, or cardiac conditions were excluded from the study.

After obtaining informed consent, all participants underwent a transabdominal ultrasound examination performed by a qualified Radiologist using a GE LOGIQ P7 machine equipped with a 2–5 MHz curvilinear transducer. The umbilical artery was first located in B-mode, followed by color Doppler to confirm the vessel and obtain waveforms. Doppler indices including S/D ratio, PI, and RI were recorded with the patient in supine position. The Doppler sample was obtained from a umbilical cord's free loop or near the placental insertion site. Each Doppler measurement was repeated and averaged over three cardiac cycles during fetal inactivity and in the absence of fetal breathing movements.

Doppler indices were considered abnormal when the S/D ratio, PI, or RI exceeded two standard deviations above the mean for the respective gestational age, based on established reference values.

All data were analyzed using SPSS version 20.0. An Independent t-test was applied to compare mean Doppler indices between the hypertensive and normotensive groups. A p-value of <0.05 was considered statistically significant at the 95% confidence level.

RESULTS

A total of 100 pregnant women were included in this study, divided equally into hypertensive ($n = 50$) and non-hypertensive ($n = 50$) groups. Table-I summarizes the baseline characteristics. The mean maternal age was comparable between groups, with non-hypertensive women averaging 27.66 ± 4.23 years and hypertensive women averaging 26.92 ± 4.03 years ($p > 0.05$). Gestational age at the time of scan was also similar, whether expressed in days (247.42 ± 19.07 vs. 250.96 ± 16.54) or weeks (35.35 ± 2.72 vs. 35.85 ± 2.36) ($p > 0.05$).

Variable	Non-Hypertensive (Mean ± SD)	Hypertensive (Mean ± SD)
Age (years)	27.66 ± 4.23	26.92 ± 4.03
Gestational Age (days)	247.42 ± 4.23	250.96 ± 16.54
Gestational Age (Weeks)	35.35 ± 2.72	35.85 ± 2.36

Table-I. Baseline characteristics of study participants

Table-II shows the umbilical artery Doppler indices. Marked differences were observed between groups. The mean Pulsatility Index (PI) was significantly higher in hypertensive pregnancies (1.260 ± 0.254) compared to non-hypertensive pregnancies (0.808 ± 0.129). Figure-1 shows this difference as a boxplot, while Figure-2 displays the overall distribution of PI values in the study population. The histogram indicates a moderately right-skewed pattern, with most non-hypertensive cases clustered at lower values and hypertensive cases extending toward higher values.

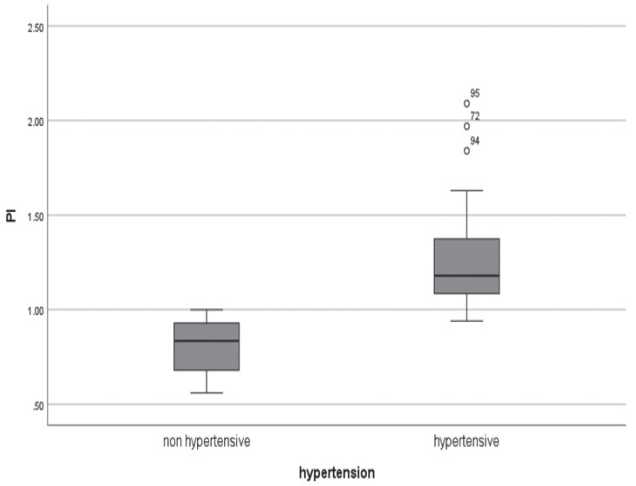

Figure-1

The Resistance Index (RI) also differed between groups, with higher values in hypertensive women (0.725 ± 0.059 vs. 0.546 ± 0.065), reflecting increased vascular resistance. This difference is shown in Figure-3.

The Systolic/Diastolic (S/D) ratio showed the most pronounced variability, with a mean of 4.08 ± 4.04 in hypertensive women compared to 2.08 ± 0.27 in non-hypertensive women. Figure-4 illustrates this using a boxplot, which shows a much wider range and several extreme outliers in hypertensive pregnancies.

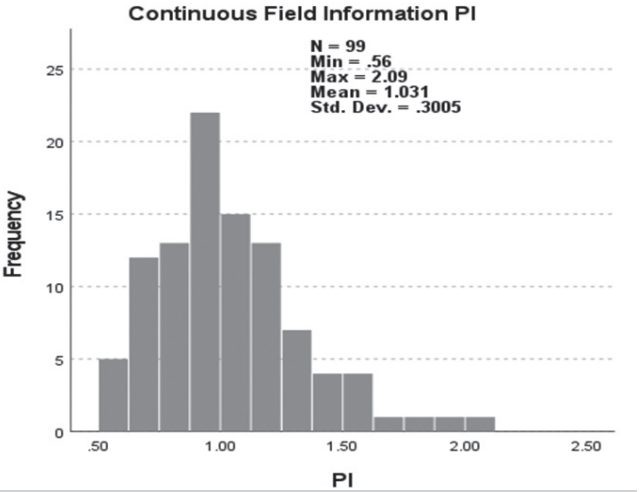

Figure-2

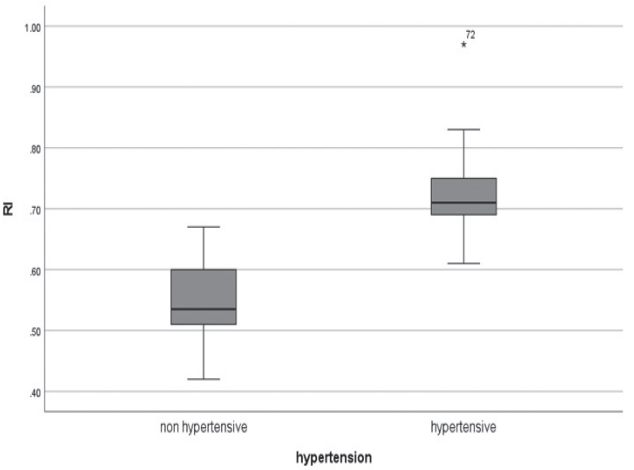

Figure-3

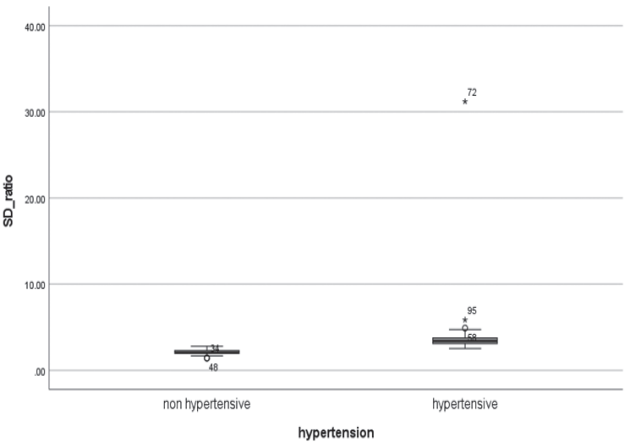

Figure-4

All these Doppler parameters showed statistically significant group differences ($p < 0.001$), indicating altered umbilical artery hemodynamics associated with hypertensive disorders.

Variable	Non-Hypertensive (Mean ± SD)	Hypertensive (Mean ± SD)	P- Value
Pulsatility Index (PI)	0.808 ± 0.129	1.260 ± 0.254	<0.001
Resistance Index (RI)	0.546 ± 0.065	0.725 ± 0.059	<0.001
Systolic/ Diastolic Ratio (S/D)	2.08 ± 0.27	4.08 ± 4.04	<0.001

Table-II. Umbilical artery Doppler indices

Table-III summarized the results of the Mann–Whitney U tests, which compared Doppler indices between hypertensive and non-hypertensive groups. The analysis showed that the RI, PI and S/D ratio were all significantly higher in hypertensive pregnancies ($p < 0.001$ for each comparison). These results indicate that maternal hypertension is associated with increased umbilical artery resistance and altered blood flow patterns, demonstrating a clear difference in vascular characteristics between two groups.

Variable	U Statistics	P-Value
Pulsatility Index (PI)	2430.5	<0.001
Resistance Index (RI)	2477.5	<0.001
Systolic/Diastolic Ratio (S/D)	2498.0	<0.001

Table-III. Mann-Whitney U Test results

DISCUSSION

This study aimed to evaluate and compare the Doppler indices of umbilical artery - Resistance Index (RI), Pulsatility Index (PI), and Systolic to Diastolic (S/D) ratio in pregnant women with pregnancy induced hypertension (PIH) and those with normotensive pregnancies during the third trimester. The findings demonstrate a statistically significant increase in all three Doppler indices in the PIH compared to normotensive group, indicating increased placental vascular resistance and impaired fetoplacental circulation in PIH. In our study, the mean PI in the PIH women was 1.41 ± 0.27, significantly higher than 0.89 ± 0.15 in the normotensive pregnancies. The RI was 0.73 ± 0.07 in hypertensive patients versus 0.61 ± 0.05 in controls. Similarly, the S/D ratio was markedly elevated in the PIH group (3.33 ± 0.58) compared to the control group (2.18 ± 0.27). These differences were statistically significant ($p < 0.001$).

These results align closely with previous studies. Rasool et al., reported higher mean Doppler indices in hypertensive pregnancies, compared to normotensive pregnancies, reporting PI values of 1.049 in normotensive women versus 1.360 in hypertensive cases, RI of 0.63 versus 0.743, and S/D ratios of 2.672 versus 3.818, respectively.[10] Similarly, Ranjumoni et al found elevated values in PIH pregnancies with a mean PI of 1.18 ± 1.21, RI ranging from 0.59 to 0.66, and S/D ratio between 2.70 and 2.98, supporting the evidence of elevated vascular resistance in hypertensive pregnancies.[11] Another study also reported elevated indices in hypertensive pregnancies, with PI 0.9, RI 0.7, and S/D 2.9, again aligning with the pattern observed in our study.[12]

Moreover, V Krishnaveni et al., observed mean PI of 1.42, RI 0.62 and S/D ratio 3.28 in PIH cases.[13] Sui Liu Et al., also reported significantly different values between two groups: in the control group, PI was 0.96, RI 0.64 and S/D ratio 3.59 while in PIH group, PI was 1.48, RI 0.85 and S/D ratio 4.31.[14] Similarly, Mujawar et al., reported elevated PI and RI values of 1.32 and 0.68, respectively, in PIH pregnancies.[15]

The elevated Doppler indices observed in PIH patients reflect increased impedance to blood flow in the fetoplacental circulation, which can result from abnormal trophoblastic invasion and poor placentation. These hemodynamic alterations may compromise oxygen and nutrient delivery to the fetus, contributing to adverse outcomes such as intrauterine growth restriction (IUGR), low birth weight, and increased perinatal morbidity.

Overall, the findings of this study reinforce the clinical utility of umbilical artery Doppler velocimetry in the surveillance of high-risk pregnancies. Regular Doppler assessments can facilitate early detection of compromised

placental function, allowing for timely intervention to improve perinatal outcomes.

CONCLUSION

This study found that the Doppler indices of umbilical artery - RI, PI, and S/D ratio were significantly higher in women with pregnancy-induced hypertension compared to normotensive pregnancies, indicating increased placental resistance. So, Early detection of abnormal indices can help guide timely interventions, improving perinatal outcomes in hypertensive pregnancies.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Shamoona Rashid:** Manuscript writing.
2	**Sadia Zafar:** Study concept and design.
3	**Hafiza Shagufta Batool:** Proof reading,
4	**Anusha Khalid:** Critical revisions,