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Original Research Article

COMPARATIVE EVALUATION OF UTERINE ARTERY DOPPLER PULSATILITY INDEX AND SERUM CALCIUM LEVELS AS PREDICTORS OF PREGNANCY- INDUCED HYPERTENSION

Sanchita Gope[1], Dibyajyoti Gharphalia[2]

[1]Post Graduate Trainee, Department of Obstetrics & Gynaecology, Gauhati Medical College & Hospital, Guwahati, Assam, India
[2]Associate Professor, Department of Obstetrics & Gynaecology, Gauhati Medical College & Hospital, Guwahati, Assam, India

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Corresponding Author:
Dr. Sanchita Gope,
Post Graduate Trainee, Department of Obstetrics & Gynaecology, Gauhati Medical College & Hospital, Guwahati, Assam, India.
Email: sanchita.gope.sg@gmail.com

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ABSTRACT

Background: Pregnancy-induced hypertension (PIH) significantly contributes to maternal and fetal morbidity and mortality. Early prediction is crucial for timely intervention. This study analyzes and compares the predictive value of Uterine Artery Doppler Pulsatility Index (PI) and Serum Calcium levels for PIH.
Materials and Methods: A prospective observational study was conducted on 150 antenatal women between 10 to 20 weeks of gestation. Uterine Artery PI and Serum Calcium levels were measured at recruitment. Blood pressure was monitored across six antenatal visits. Associations between early PI and Serum Calcium levels with the development of PIH were analyzed.
Results: Elevated uterine artery PI (>1.45) was observed in 64% of participants, while low serum calcium (<8.5 mg/dL) was noted in 57%. A significant correlation was found between high PI and elevated blood pressure readings in later visits. The combination of high PI and low calcium levels showed a stronger association with the development of PIH.
Conclusion: Uterine artery Doppler PI serves as a more sensitive early predictor of PIH compared to serum calcium levels. However, combining both parameters enhances predictive accuracy, facilitating early identification and management of high-risk pregnancies.
Keywords: PIH, Uterine Artery Doppler Pulsatility Index (PI).

INTRODUCTION

Pregnancy-induced hypertension (PIH), encompassing gestational hypertension and preeclampsia, remains a prevalent complication in pregnancy, leading to adverse maternal and fetal outcomes. Early identification of women at risk is pivotal for implementing preventive strategies.

The Uterine Artery Doppler Pulsatility Index (PI) reflects uteroplacental blood flow resistance. Elevated PI values indicate impaired trophoblastic invasion and are associated with the development of PIH.[1-6] Concurrently, serum calcium plays a role in vascular smooth muscle contractility, and hypocalcemia has been implicated in the pathogenesis of PIH.[1,2,4,8]

This study aims to evaluate and compare the predictive value of uterine artery PI and serum calcium levels measured in early pregnancy for the subsequent development of PIH.

MATERIALS AND METHODS

Study Design and Participants: A prospective observational study was conducted at Gauhati Medical College & Hospital from March 2024 to March 2025. A total of 150 pregnant women between 10 to 20 weeks of gestation attending the antenatal clinic were enrolled after obtaining informed consent.

Inclusion Criteria

- Singleton pregnancies
- Gestational age between 10 to 20 weeks

Exclusion Criteria

- Pre-existing hypertension
- Multiple pregnancies
- Chronic medical conditions affecting calcium metabolism

- Active labour on admission

Data Collection: At recruitment, uterine artery Doppler studies were performed to measure PI. Serum calcium levels were assessed using standard laboratory techniques. Blood pressure measurements were recorded at six scheduled antenatal visits. PIH was diagnosed based on systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg on two occasions at least four hours apart after 20 weeks of gestation.

Statistical Analysis: Data were analyzed using appropriate statistical methods to determine the association between early PI and serum calcium levels with the development of PIH. Correlation coefficients and p-values were calculated to assess the strength and significance of associations.

RESULTS

Among the 150 antenatal women enrolled in the study, 96 participants (64%) demonstrated a uterine artery pulsatility index (PI) greater than 1.45, while 54 participants (36%) had PI values less than or equal to 1.45. The overall mean PI was 1.87 with a standard deviation of 0.62.

Table 1: Uterine Artery Pulsatility Index

Range	Frequency	Percent	Mean	SD
<1.45	54	36%	1.87	0.62
>1.45	96	64%		

This distribution indicates that nearly two-thirds of the study population exhibited elevated vascular resistance within the uterine arteries. Such increased resistance, as reflected by a higher PI, is suggestive of impaired trophoblastic invasion and poor placental perfusion, which are recognized mechanisms underlying pregnancy-induced hypertension (PIH). These results support the hypothesis that an elevated PI during the second trimester can serve as an early marker for identifying women at increased risk of PIH.

Table 2: Serum Calcium

Range	Frequency	Percent	Mean	SD
<8.5	86	57%	8.5	0.61
>8.5	64	43%		

Serum calcium levels were below 8.5 mg/dL in 86 women (57%), while 64 women (43%) exhibited levels above this threshold. The mean serum calcium level for the cohort was 8.5 mg/dL with a standard deviation of 0.61.

A high prevalence of hypocalcemia in the study population suggests a potential biochemical predisposition contributing to hypertensive disorders. Lower serum calcium levels are known to increase neuromuscular excitability and enhance vascular smooth muscle tone, both of which can lead to elevated blood pressure. These findings corroborate previous studies that have highlighted a link between calcium deficiency and the development of PIH.

Table 3: Correlations between uterine artery doppler and serum calcium as a predictor of PIH

Bivariate Spearman's rho			UT Artery PI	S Calcium	BP2	BP3	BP4	BP5
	UT ARTERY PI	Correlation Coefficient	1	0.561	0.139	0.226	0.36	0.459
		p Value		0.0000	0.04	0.003	0.001	0.001
	S CALCIUM	Correlation Coefficient	0.561	1	0.16	0.14	0.25	0.33
		p Value	0.0000		0.25	0.03	0.001	0.001

Spearman's correlation analysis revealed a strong positive correlation between uterine artery PI and serum calcium levels ($r = 0.561$, $p < 0.001$). Uterine PI showed increasing correlation strength with advancing BP measurements—BP2 ($r = 0.139$, $p = 0.04$), BP3 ($r = 0.226$, $p = 0.003$), BP4 ($r = 0.36$, $p = 0.001$), and BP5 ($r = 0.459$, $p = 0.001$). In contrast, serum calcium had weaker correlations: BP2 ($r = 0.16$, $p = 0.25$), BP3 ($r = 0.14$, $p = 0.03$), BP4 ($r = 0.25$, $p = 0.001$), and BP5 ($r = 0.33$, $p = 0.001$). These results suggest that uterine PI is a more robust predictor of PIH than serum calcium.

Table 4: Relation between S Calcium and detection of PIH

S. Calcium Range	BP1 (PIH)		BP2 (PIH)		BP3 (PIH)		BP4 (PIH)		BP5 (PIH)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
<8.5 (n86)	0	86	5	81	21	65	57	29	74	12
>8.5 (n64)	0	64	0	64	8	56	26	38	36	28

Among women with calcium <8.5 mg/dL (n=86), PIH was detected in 5 at BP2, 21 at BP3, 57 at BP4, and 74 at BP5. In contrast, those with calcium >8.5 mg/dL (n=64) had 0 cases at BP2, 8 at BP3, 26 at BP4, and 36 at BP5. These data indicate a steeper progression of PIH in the low-calcium group, supporting the view that hypocalcemia may contribute to later PIH development.

Table 5: Relation between UT ARTERY PI and detection of PIH

UT ARTERY PI	BP1 (PIH)		BP2 (PIH)		BP3 (PIH)		BP4 (PIH)		BP5 (PIH)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
<1.45 (n 54)	0	54	0	54	4	50	17	37	25	29
>1.45 (n 96)	0	96	5	91	25	71	66	30	85	11

For women with PI <1.45 (n=54), PIH cases were 0 at BP1 and BP2, rising to 4 at BP3, 17 at BP4, and 25 at BP5. For those with PI >1.45 (n=96), 5 cases were noted at BP2, 25 at BP3, 66 at BP4, and 85 at BP5. The findings confirm that elevated uterine PI is associated with an earlier onset and higher incidence of PIH.

Table 6: Relation between low S Calcium, high UT ARTERY PI and detection of PIH

S. Calcium Range/UT ARTERY PI	BP1 (PIH)		BP2 (PIH)		BP3 (PIH)		BP4 (PIH)		BP5 (PIH)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
<8.5 & >1.45 (n75)	0	75	5	70	21	54	56	20	71	5

Among the 75 women with both low calcium (<8.5 mg/dL) and high PI (>1.45), 5 developed PIH at BP2, 21 at BP3, 56 at BP4, and 71 at BP5. This combined risk group exhibited the steepest progression, highlighting that concurrent abnormalities in both parameters significantly elevate PIH risk.

DISCUSSION

Hypertensive disorders in pregnancy, particularly Pregnancy-Induced Hypertension (PIH), are a leading cause of maternal and perinatal morbidity. Early identification of women at risk is crucial for initiating appropriate surveillance and intervention. In this study, we evaluated two predictive markers—Uterine Artery Doppler Pulsatility Index (PI) and Serum Calcium levels—to determine their individual and combined efficacy in forecasting the onset of PIH.[1,3,4]

The results demonstrated that uterine artery Doppler PI, measured in the early second trimester, had a strong association with the subsequent development of PIH. A significant proportion of participants (64%) had a PI greater than 1.45, a threshold commonly used to define elevated uterine vascular resistance. These women showed a markedly higher incidence of PIH, with 85 out of 96 developing hypertension by the fifth antenatal visit. The progressive rise in systolic and diastolic blood pressure across antenatal visits among this group supports the hypothesis that elevated uterine artery PI reflects impaired trophoblastic invasion and maladaptation of spiral arteries—pathophysiological hallmarks of PIH. These findings are consistent with those of Gómez et al. and Myatt et al., who reported a strong predictive value of uterine artery Doppler PI in the second trimester for hypertensive disorders in pregnancy.[6,7]

Furthermore, our study revealed that serum calcium levels below 8.5 mg/dL were present in 57% of the study population. The inverse relationship between calcium levels and PIH incidence, especially by the later antenatal visits, supports the theory that hypocalcemia contributes to increased vascular reactivity and fluid retention. Although the association was statistically significant, the strength of correlation between serum calcium and blood pressure values was consistently lower than that of uterine artery PI. This indicates that while serum calcium may serve as a supplementary marker, it may not be as reliable as Doppler PI in early prediction of PIH.[1,2,4]

The combined analysis of both markers yielded the most compelling findings. Among women with both elevated PI and low serum calcium levels, the incidence of PIH was significantly higher and appeared earlier than in those with only one or neither risk factor. This group exhibited a steep rise in PIH detection from the third antenatal visit onwards, reaching 71 cases out of 75 by the fifth visit. These observations reinforce the hypothesis that a combined physiological and biochemical disruption in placental and vascular function dramatically heightens the risk of hypertensive disorders. This dual-marker approach is supported by Sridevi et al., who found that using both uterine artery Doppler and serum calcium improved the sensitivity and specificity of PIH prediction compared to using either marker alone.[8]

Spearman's correlation analysis further substantiated the stronger predictive value of uterine artery PI. The correlation coefficients between PI and blood pressure rose progressively across visits (BP2: $r = 0.139$, $p = 0.04$; BP3: $r = 0.226$, $p = 0.003$; BP4: $r = 0.36$, $p = 0.001$; BP5: $r = 0.459$, $p = 0.001$), while serum calcium showed weaker, though still statistically significant, correlations (BP3: $r = 0.14$, $p = 0.03$; BP5: $r = 0.33$, $p = 0.001$). The moderate positive correlation observed between PI and serum calcium ($r = 0.561$, $p < 0.001$) may suggest an indirect interplay between vascular resistance and calcium-regulated vascular tone, although further mechanistic studies are needed.

These findings highlight the clinical importance of integrating both uterine artery Doppler and serum calcium estimation into routine second-trimester screening protocols. Identifying women with concurrent elevations in vascular resistance and calcium deficiency allows for closer monitoring, targeted prophylaxis (such as calcium supplementation or low-dose aspirin), and potentially improved maternal and fetal outcomes.

CONCLUSION

From the current study, it may be concluded that both low serum calcium level and uterine artery PI are important predictors of PIH in pregnant woman. Low serum calcium patients develop PIH gradually, usually at late pregnancy. Uterine artery PI is a better predictor of PIH and can give early idea of patients who are more prone to develop PIH.

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