Role of Uterine Artery Doppler in Pregnant Woman at 11 To 24 Weeks of Gestation in Predicting Pre-Eclampsia

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Abstract

Background: Anticipating preeclampsia's onset is pivotal in mitigating adverse maternal and perinatal outcomes. This study aims to study the prognosis of preeclampsia within low-risk pregnancies by evaluating uterine artery Doppler indices within the 11-24 week gestation.

Methodology: A prospective observational study comprising 68 low-risk pregnancies (11-24 weeks gestation) underwent serial uterine artery Doppler assessments at 11-24 and 20-284weeks. Follow-up was extended to delivery to detect preeclampsia incidence.

Results: Among 68 participants, 13 (19.1%) developed preeclampsia. Sensitivity values for resistance index (RI), pulsatility index (PI), and bilateral notching were 23.1%, 46.2%, and 61.5%, respectively, during 11-14 weeks. Similarly, during 20-24 weeks, sensitivities for RI, PI, and bilateral notching were 23.1%, 38.5%, and 61.5%, respectively, with specificity exceeding 100%.

Conclusions: Bilateral notching during 11-14 weeks and integrated doppler markers within 11-14 and 20-28 weeks indicate preeclampsia susceptibility in low-risk pregnancies. Conversely, uterine artery Doppler indices at 11-24 weeks effectively rule out preeclampsia development, exhibiting a specificity of >90%.

Categories: Obstetrics/Gynecology, Radiology

Keywords: bilateral notching, uterine artery ri, uterine artery pi, preeclampsia prediction

Introduction

Hypertensive disorders are the underlying catalysts for complications in 5-10% of pregnancies. Coupled with hemorrhage and infection they form an integral facet of the perilous triad, exerting a substantial impact on maternal well-being and mortality rates [1]. Preeclampsia is a prevalent hypertensive disorder, afflicting approximately 4-7% of pregnancies and emerging as a prominent contributor to maternal mortality. Globally, preeclampsia impacts around 2-5% of expectant mothers, tragically accounting for the loss of approximately 76,000 women and 500,000 infants each

year [2]. The incidence and prevalence of preeclampsia and eclampsia in India are notably elevated, with rates at approximately 28% and 7.4-11.3%, respectively, surpassing their global occurrences [3]. In the northeast part of India, the incidence of preeclampsia is 9.7% [4]. In Assam, pregnancy-induced hypertension (PIH) (17.3%) is the major cause of maternal death [5]. Preeclampsia is linked to several common obstetric complications, including intrauterine fetal death; fetal growth restriction; preterm delivery; hemolysis, elevated liver enzymes, low platelet count syndrome; and eclampsia. Furthermore, non-obstetric complications encompass heart failure, peripartum cardiomyopathy, pulmonary edema, heightened susceptibility to future cardiovascular disease, posterior reversible encephalopathy syndrome, stroke, renal failure, acute kidney injury, liver failure, and coagulopathy [6]. Accurate prediction of preeclampsia remains elusive, lacking definitive early pregnancy markers for distinguishing high-risk individuals. Thus, obstetric care primarily centers on early detection; while delivery is the ultimate treatment, proactive measures such as vigilant monitoring and secondary prevention are valuable. Early diagnosis is pivotal for optimized maternal and perinatal outcomes through effective management.

The origin of preeclampsia lies in placental dysfunction, notably impaired uterine spiral artery dilation causing placental ischemia. In healthy pregnancies, controlled trophoblastic invasion remodels spiral arteries, ensuring optimal uteroplacental blood flow. In preeclampsia-prone pregnancies, shallow trophoblastic invasion leaves deep arterioles with retained endothelium, resulting in reduced vessel diameter and blood flow. Early identification of preeclampsia and placental insufficiency is crucial for timely intervention, mitigating maternal and perinatal risks. Our institution lacks serological preeclampsia tests. Maternal uterine artery (UA) Doppler studies have shown superior predictive ability over traditional methods, albeit with variable parameters, protocols, and sensitivity for hypertensive disorders [7].

Predominantly, investigations have concentrated on UA Doppler during the second trimester, aligning with the completion of trophoblastic invasion of maternal spiral arteries. Some scholars have advocated for dual assessment in both the first and second trimesters. Although UA Doppler has gained recognition as a reliable tool for predicting hypertensive disorders in high-risk pregnancies, its utilization within low-risk cohorts remains limited. In regions marked by elevated maternal mortality, where hypertensive disorders wield substantial impact, this study was undertaken within a low-risk demographic. Notably, over half of the women facing such complications lack identifiable risk factors in their history. Employing UA Doppler velocimetry between the 14th and 28th weeks of gestation, this study bears significance.

Materials and Methods

The study was a Prospective observational study among 68 women visiting OPD in the Department of OBG at SSMC between January to December 2024. The inclusion and exclusion criteria were considered

Clinical assessments included measurements of blood pressure after a 10-minute rest, maternal weight, and fundal height during each visit. Routine urine and blood tests were conducted, with urinary protein estimation performed. UA Doppler recordings were acquired twice: first between 11 and 16 weeks of gestation and then between 20 and 28 weeks particularly in differentiating between early and late preeclampsia

The procedure involved obtaining a mid-sagittal section of the uterus and visualizing the internal cervical os and cervical canal. The transducer was then gently tilted to identify the right and left uterine arteries using color flow mapping along the uterine cervix's side, specifically at the internal os level. Pulsed-wave Doppler with a sampling gate set at 3 mm was employed to capture the complete vessel width. The signal was refined until three consistent waveforms were obtained. Mean values were calculated for pulsatility index (PI), resistive index (RI), notch deep index (NDI), and bilateral diastolic notches, recorded between 11-16 weeks and 20-24 weeks of gestation.

Uterine Doppler values were deemed abnormal if RI and PI values exceeded the 95th percentile for the corresponding gestational age, along with bilateral diastolic notches. Standard RI and PI values for the 95th percentile were adopted from prior studies, as well as considering the presence of bilateral diastolic notches.

Inclusion Criteria

1. Intrapartum complications in all women with previous caesarean section including placenta previa

Results

Table 1: Demographic details of study

1 a: Maternal Age

Maternal Age	Frequency	Percent
<=25	13	19.1
26-30	44	64.7
>30	11	16.2
Total	68	100.0

Table 1a Shows number of patients and the age group of the same.

1 b: Gravidity Distribution

Gravidity	Frequency	Percent
1	12	17.6
2	42	61.8

and abnormally adherent placenta will be noted.
Pregnant woman with Age between 18- 35 years
2. Gestational age between 11-24 weeks
3. Patient who have consented for the procedure

Exclusion Criteria

1. Patient who refuse to participate or consenting for the study.
2. Patients who are lost to follow up.

Statistical Analysis

Data were analyzed using SPSS version 22.0. Descriptive statistics were used to summarize demographic and clinical characteristics. Categorical variables were analyzed using the chi-square test, while continuous variables were compared using t-tests. The sensitivity, specificity, positive predictive value, and negative predictive value of MRI were calculated. A p-value of <0.05 was considered statistically significant, ensuring robust conclusions.

3	11	16.2
4	3	4.4
Total	68	100.0

Table 1b Shows the gravidity of the mothers in the study with maximum with gravida 2

Table 2: Prevalence of preeclampsia

Term-Pe & Eclampsia	Frequency	Percent
Positive	13	19.1
Negative	55	80.9
Total	68	100.0

Table 2 Shows significant distribution of Pre-Eclampsia in the study population. Around 13 among 68 had pre-eclampsia
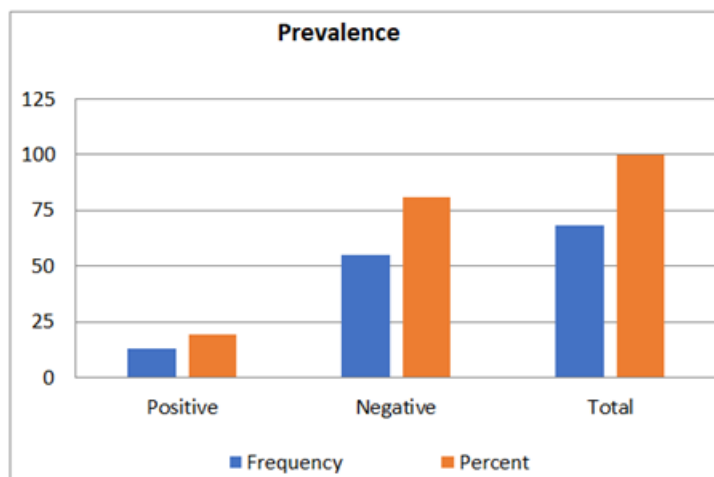
Chart 1:

Table 3: Ut. Artery RI Index 11-13 Weeks

RI_3M	Frequency	Percent	PE & ECLAMPSIA (+)
Present	3	4.4	3
Absent	65	95.6	10
Total	68	100.0	13

Table 3 Shows significant Resistant Index of Uterine Artery between 11-13weeks of gestation in the study population.

Around 3 among 68 showed positive

Table 4: Ut. Artery PI index 11-13 weeks

PI_3M	Frequency	Percent	PE & ECLAMPSIA (+)
Present	6	8.8	6
Absent	62	91.2	7
Total	68	100.0	13

Table 4 Shows significant Pulsatile Index of Uterine Artery between 11-13weeks of gestation in the study population.

Around 6 among 68 showed positive

Table 5: Ut. Artery Notching 11-13 weeks

UTART.NOTCH_3M	Frequency	Percent	PE & ECLAMPSIA (+)
Present	10	14.7	8
Absent	58	85.3	5
Total	68	100.0	13

Table 5 Shows significant Uterine Artery notching between 11-13weeks of gestation in the study population. Around 10 among 68 showed positive

Table 6: Sensitivity, Specificity, PPV, NPV, diagnostic accuracy and relative risk (11-13weeks)

	Sensitivity	Specificity	PPV	NPV	Accuracy	Risk Ratio
RI_3M	23.1%	100.0%	100.0%	84.6%	85.3%	6.50
PI_3M	46.2%	100.0%	100.0%	88.7%	89.7%	8.86
UT.ART.NOTCH_3M	61.5%	96.4%	80.0%	91.4%	89.7%	9.28
RI_PI_3M	46.2%	100.0%	100.0%	88.7%	89.7%	8.86
RI_Notch_3M	61.5%	96.4%	80.0%	91.4%	89.7%	9.28
PI_Notch_3M	61.5%	96.4%	80.0%	91.4%	89.7%	9.28
PI_RI_Notch_3M	61.5%	96.4%	80.0%	91.4%	89.7%	9.28

Table 6 Shows significant Sensitivity, Specificity, PPV, NPV, diagnostic accuracy and relative risk between 11-13 weeks of gestation of individual and combined parameters
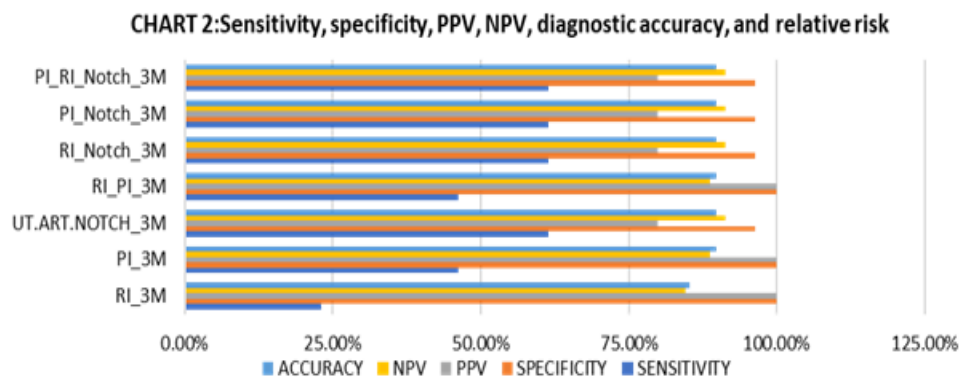
Chart 2:

CHART 2:Sensitivity, specificity, PPV, NPV, diagnostic accuracy, and relative risk

Table 7: Ut. Artery RI index 20-24weeks

RI_6M	Frequency	Percent	PE & ECLAMPSIA (+)
Present	3	4.4	3
Absent	65	95.6	10
Total	68	100.0	13

Table 7 Shows significant Resistant Index of Uterine Artery between 20-24weeks of gestation in the study population. Around 3 among 68 showed positive

Table 8: Ut. Artery PI index 20-24weeks

PI_6M	Frequency	Percent	PE & ECLAMPSIA (+)
Present	5	7.4	5
Absent	63	92.6	8
Total	68	100.0	13

Table 8 Shows significant Pulsatile Index of Uterine Artery between 20-24weeks of gestation in the study population. Around 5 among 68 showed positive

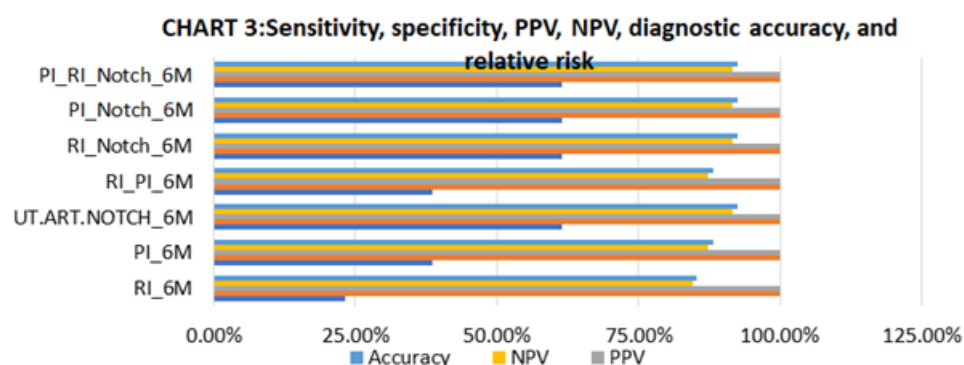Table 9: Ut. Artery Notching 20-24weeks

UT.ART.NOTCH_6M	Frequency	Percent	PE & ECLAMPSIA (+)
Present	8	11.8	8
Absent	60	88.2	5
Total	68	100.0	13

Table 9 Shows Uterine artery notching between 20-24weeks of gestation in the study population. Around 8 among 68 showed positive

Table 10: Sensitivity, Specificity, PPV, NPV, diagnostic accuracy and relative risk (20-24weeks)

	Sensitivity	Specificity	PPV	NPV	Accuracy	Risk Ratio
RI_6M	23.1%	100.0%	100.0%	84.6%	85.3%	6.50
PI_6M	38.5%	100.0%	100.0%	87.3%	88.2%	7.88
UT.ART.NOTCH_6M	61.5%	100.0%	100.0%	91.7%	92.6%	12.00
RI_PI_6M	38.5%	100.0%	100.0%	87.3%	88.2%	7.88
RI_Notch_6M	61.5%	100.0%	100.0%	91.7%	92.6%	12.00
PI_Notch_6M	61.5%	100.0%	100.0%	91.7%	92.6%	12.00
PI_RI_Notch_6M	61.5%	100.0%	100.0%	91.7%	92.6%	12.00

Chart 3:

CHART 3:Sensitivity, specificity, PPV, NPV, diagnostic accuracy, and relative risk

Discussion

Among the cohort of 68 women studied, 13(19.1%) developed preeclampsia. The prevalence of preeclampsia observed in this study is consistent with Shashi et al.'s findings (20%) and notably higher than the prevalence reported by Scandiuzzi et al. (9.2%) in 2016 and Myatt

et al. (6.7%) in 2012. [7-9]. Within the group of 68 women, 10 (14.7%) exhibited notching during the 11-13 week period. The persistence of notching was observed in 11.7% during the 20-24 week interval, comparable to the findings of Myatt et al. (14%). Additionally, Harrington et al. documented preeclampsia in 16% of women displaying bilateral notching at 12-16 weeks of gestation [7,8].

Variables	Reference Name	Reference Value	Observed Value	Inference
Sensitivity	Shubrath et al., 2023	11-13WEEKS: RI:17.64% Notch:71% PI:56.25% PI+RI:63.2% RI+PI+NOTCHING:82.5% 20-24WEEKS: RI:16.6% notch:55.5% PI:36.8% PI+RI:45.4% RI+PI:63.6%	11-13WEEKS: RI:23.1% Notch: 61% PI:46.2% PI+RI:46.2% RI+PI+NOTCHING:61.5% 20-24WEEKS: RI:23.1% PI:38% RI+PI:61.5%	Comparable with the present study.
Specificity	Shubrath et al., 2023	11-13WEEKS: RI:93.2% Notch: 91.5% PI:92.6% PI+RI:94.4% RI+PI+NOTCHING:96.8% 20-24WEEKS: RI:93.8% Notch: 93.8% PI:94.4% PI+RI:96.2% RI+PI+NOTCHING:96.2%	11-13WEEKS: RI:100% Notch: 96.4% PI:100% PI+RI:100% RI+PI+NOTCHING:96.4% 20-24WEEKS: RI:100% Notch: 100% PI:100% PI+RI:100% RI+PI+NOTCHING:100%	Comparable with the present study.
PPV:	Shubrath et al., 2023	11-13WEEKS: RI:43% Notch: 64.3% PI:63.3% PI+RI:62.1% RI+PI+NOTCHING:78% 20-24WEEKS:	11-13WEEKS: RI:100% Notch: 80% PI:100% PI+RI:100% RI+PI+NOTCHING:80% 20-24WEEKS:	PPV observed in the study shows better results which could be due to fewer study group

		RI:41% Notch: 68% PI:64.7% PI+RI:76.5% RI+PI+NOTCHING:83%	RI:100% Notch: 100% PI:100% PI+RI:100% RI+PI+NOTCHING:100%	
NPV:	Shubrath et al., 2023	11-13WEEKS: RI:91.5% Notch: 97.4% PI:95.5% PI+RI:95.5% RI+PI+NOTCHING:97.4% 20-24WEEKS: RI:91.01% Notch: 95% PI:92.6% PI+RI:92.5% RI+PI+NOTCHING:95%	11-13WEEKS: RI:84.6% Notch: 91.4% PI:88.7% PI+RI:88.7% RI+PI+NOTCHING:91.4% 20-24WEEKS: RI:84.6% Notch: 91.7% PI:87.3% PI+RI:87.3% RI+PI+NOTCHING:91.7%	Comparable with the present study.
Accuracy:	Shubrath et al., 2023	11-13WEEKS: RI:86.1% Notch: 90% PI:89.4% PI+RI:89% RI+PI+NOTCHING:97.4% 20-24WEEKS: RI:86.1% Notch: 90% PI:88.3% PI+RI:90% RI+PI+NOTCHING:95%	11-13WEEKS: RI:85.3% Notch: 89.7% PI:89.7% PI+RI:89.7% RI+PI+NOTCHING:89.7% 20-24WEEKS: RI:85.3% Notch: 92.6% PI:88.2% PI+RI:88.2% RI+PI+NOTCHING:92.6%	Comparable with the present study.

In our study, UA RI values exceeding the 95th percentile >0.70were 4.41% for both the 11-13 week and 20-24week periods of pregnancy. These thresholds were derived from prior investigations, such as the study by Scandiuzzi et al., who established 0.77 as the mean RI [7]. In the context of the second trimester, Valensise et al. evidenced that a mean UA RI exceeding 0.58 served as a reliable predictor of hypertensive disorders. [11]. Albaiges et al. evaluated pregnant women at 23 weeks of gestation and obtained a mean UA RI of 0.69 (95th percentile) [10]. When considering UA PI values exceeding the 95th percentile for gestational age, 6 women at 11-13 weeks (8.8%) and 5 women at 20-24 weeks (7.34%) exhibited

such values. These findings were statistically significant compared to the non-preeclampsia group (p < 0.0001).

To summarize the research findings, at the 14-20 week gestational range, the presence of the bilateral diastolic notch alongside an NDI exceeding 0.14 can be considered as a standalone predictor for preeclampsia. Enhanced prediction is achieved through combined indices, such as bilateral diastolic notch + PI or RI, and PI + RI. However, during the 20-28 week window, no single indicators suffice for preeclampsia prediction. Acceptance is marginally warranted for the combined indices PI + RI + bilateral notching. Throughout both trimesters, all UA Doppler indices are suitable for ruling out preeclampsia development.

However, this study has some limitations, particularly in differentiating between early and late preeclampsia due to limited data, including cases with information gathered via telephonic contact and from deliveries in other institutions.

The broader implication of this research lies in its practical applicability. In settings where serological tests are unavailable but ultrasound expertise is present in outpatient clinics, low-risk pregnant women can be screened during their first-trimester ultrasound. Utilizing UA Doppler indices, including the presence of a bilateral diastolic notch, PI exceeding the 95% cutoff level (1.8), RI surpassing the 95% cutoff level (0.7), and NDI surpassing 0.14, could serve as indicators for predicting preeclampsia. These indicators can be employed during both trimesters to exclude the likelihood of future preeclampsia, given the study's high specificity results.

Conclusions

Preeclampsia is an intricate clinical syndrome impacting multiple organ systems and bearing substantial consequences for maternal and perinatal mortality and morbidity. UA indices that signify resistance within the uteroplacental circulation, namely, PI, bilateral notching, and NDI >0.14, display notable elevations in preeclampsia cases. This suggests that the resistance to blood flow holds greater significance than the sheer blood flow volume. UA indices such as PI and NDI emerge as superior predictors for preeclampsia development within low-risk pregnancies, particularly during the 14-20 week gestational window. Furthermore, in both the first and second trimesters, these indices exhibit the potential for ruling out the likelihood of preeclampsia development, as evidenced by significantly elevated specificity and NPV.

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