Study of First Trimester Uterine Artery Doppler Screening for Predicting Adverse Pregnancy Outcomes

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ABSTRACT

Background

Hypertensive disorders of pregnancy are the second leading cause of maternal and perinatal morbidity and mortality, complicating 5–10% of pregnancies. Early detection and prophylactic interventions can reduce adverse outcomes. First-trimester uterine artery Doppler is a noninvasive tool for predicting and detecting abnormal placental perfusion.

Objective

To determine the role of first-trimester uterine artery pulsatility index (PI) in predicting hypertensive disorders and adverse pregnancy outcomes and to evaluate pregnancy outcomes in patients with abnormal uterine artery Doppler who are treated with aspirin.

Method

A prospective cohort study was conducted at Dhulikhel Hospital for one year period. Uterine artery Doppler was performed at 11 to 13 weeks 6 days, and mean PI ≥ 1.5 was abnormal and normal if pulsatility index < 1.5. Women with PI ≥ 1.5 received low-dose aspirin 150 mg until 34 weeks. Participants were followed until delivery; maternal and fetal outcomes were recorded. Statistical analyses were done with $p < 0.05$ considered significant.

Result

Of 202 women, 177 (87.6%) had PI ≥ 1.5. Hypertension developed in 25 cases (12.4%), predominantly in the high-PI group. First-trimester PI had a sensitivity of 96% and specificity of 13.6% for predicting hypertension. Complications included hemolysis, elevated liver enzyme and low platelet (HELLP) and abruptio in 1%, oligohydramnios 7.43%, fetal growth restriction (FGR) 18.8% and stillbirth 0.5%.

Conclusion

First trimester uterine artery Doppler ultrasound is a valuable screening tool for early prediction of adverse pregnancy outcomes and should be implemented in prenatal care protocol. Starting low dose aspirin in early pregnancy improves placental perfusion reducing maternal and fetal complications.

KEY WORDS

Aspirin, Doppler ultrasound, Fetal growth restriction, Hypertension, Preeclampsia, Pregnancy outcome

INTRODUCTION

Hypertensive disorders of pregnancy are the second leading cause of maternal and perinatal morbidity and mortality worldwide, affecting 5-10% of pregnancies.[1] Preeclampsia is a multisystem disorder marked by the onset of hypertension after 20 weeks of gestation with proteinuria or signs of end organ dysfunction.[2] Fetal problems of preeclampsia are preterm delivery, FGR, and respiratory distress syndrome. Maternal complications are acute renal failure, placenta abruptio, pulmonary oedema, intraventricular hemorrhage, disseminated intravascular coagulopathy and HELLP syndrome.[3]

Early identification followed by timely prophylaxis and treatment is critical to reducing the risks of preeclampsia. Several approaches are used for prediction, including clinical risk factors, biochemical markers, and uterine artery Doppler alone or in combination.[4,5] Among these, uterine artery Doppler is especially valuable: it detects abnormal placental blood flow early in the first trimester, before clinical symptoms appear.[6,7] Doppler detects high resistance flow which provides indirect underlying defective placentation which causes preeclampsia.[8] It is simple to use, repeatable, and noninvasive.[9] These qualities make it particularly applicable in low socioeconomic settings such as Nepal. Evidence suggests that low dose aspirin has protective role, reducing preterm delivery and early onset preeclampsia by 10%.[10]

This kind of research will help in the early identification of the issue and implement preventative measures to improves the pregnancy outcome. So, the purpose of this study is to determine the role of first-trimester uterine artery PI in predicting hypertensive disorders and adverse pregnancy outcomes and to evaluate pregnancy outcomes in patients with abnormal uterine artery Doppler receiving aspirin.

METHODS

This was a prospective cohort study that was carried out from 3rd February 2025 to 3rd February 2026 at Dhulikhel Hospital (DH) in the department of Obstetrics and Gynecology. The institutional review committee of Kathmandu University School of Medical Sciences (IRC, KUSMS) has obtained ethical approval for it, and it is registered under research ID IRC-KUSMS: 34/25

Sample size calculation

Sample size,

z: confidence level at 95%

p: estimated prevalence

e: confidence interval

Number of patients(N): z^2 pq/e^2

z = 1.96 for confidence interval of 95%

Prevalence(p) = 10% according to data in reference.[1]

q = 1-p = (1-0.1)

Allowable error (e) = 5%

Calculation:

N = (1.96×1.96) ×0.1×(1-0.1)/(5/100×5/100)

= 138

The estimated sample size, including a 10% dropout, was 151. However, with more patients available, the study was expanded to 202 participants after re approval from the IRC at DH. This larger sample enhances statistical power, improves accuracy, and makes the findings more reliable and significant.

The inclusion criteria for the study were all singleton pregnancies between 11 to 13 weeks 6 days and women willing to participate in the study.

The exclusion criteria included multiple pregnancy, congenital anomalies, pregnancy with fibroid uterus, chronic hypertension, patients already on aspirin and patient not willing to participate.

All eligible women attending the outpatient department were recruited after obtaining written and verbal consent. A detailed history and examination were performed, and participants were screened at each antenatal visit for symptoms of preeclampsia (headache, epigastric pain, visual disturbances) and urine albumin. Blood pressure was recorded at every visit, and routine antenatal care was provided according to departmental protocol. Maternal characteristics were documented using a structured proforma.

Uterine artery Doppler was performed at 11 to 13 weeks 6 days along with nuchal translucency and nasal bone assessment using a Chison CBit 6 ultrasound machine with a convex transducer (D3C60L, 2–6 MHz). Initially, scans were performed by a radiologist; later myself under his supervision performed all the Doppler scan. Women were examined in the supine position, and color flow mapping was used to identify the uterine arteries at the level of the internal os. Pulsed wave Doppler was applied to obtain bilateral flow velocity waveforms from the ascending branch of the uterine artery, with a 2 mm sampling gate and insonation angle < 30° (Fig. 1 and 2). The mean pulsatility index (PI) was calculated from both sides. A cutoff of PI ≥ 1.5 defined abnormal flow (Fig. 3 and 4). Women with abnormal PI were started on aspirin 150 mg daily until 34 weeks. All participants were followed until delivery, and maternal and fetal outcomes including gestational hypertension, preeclampsia, HELLP syndrome, oligohydramnios, FGR, placental abruption, prematurity, and stillbirth were recorded, along with mode of delivery, gestational age, and birth weight.

Data were entered into Excel and analyzed using SPSS version 28. Descriptive statistics summarized baseline

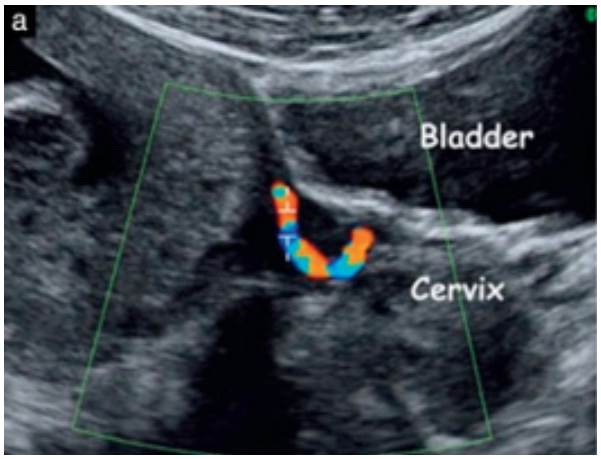

Figure 1. Location of uterine artery at cervicocorporeal junction, lateral to the cervix at the level of internal os

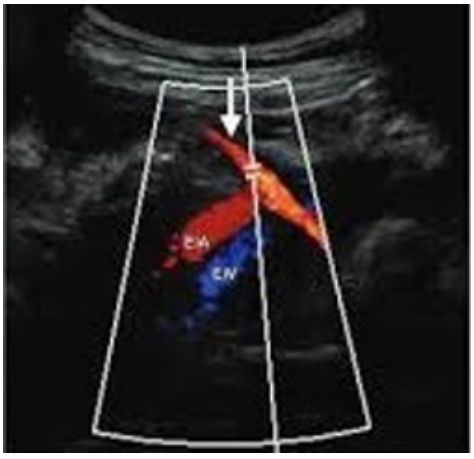

Figure 2. Alternative approach involves identifying uterine artery as it crosses over external iliac artery

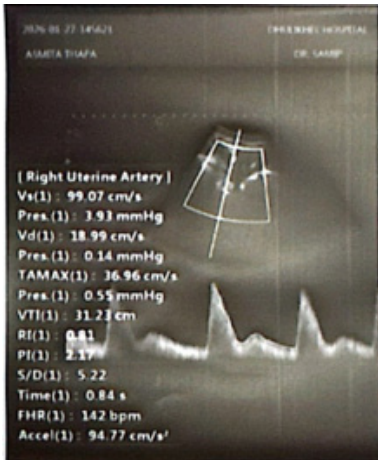

Figure 3. Transabdominal doppler ultrasound of right uterine artery Doppler showing raised pulsatility index 2.17 with early diastolic notching

Figure 4. Transabdominal doppler ultrasound of left uterine artery Doppler showing raised pulsatility index 2.13 with early diastolic notching

characteristics. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Receiver operating characteristic (ROC) curves were generated to assess Doppler performance, and sensitivity, specificity, positive predictive value, and negative predictive value were calculated. Associations between Doppler findings and pregnancy outcomes were tested using the chi square test, with $p < 0.05$ considered statistically significant.

RESULTS

The mean maternal age was 28.6 ± 4.9 years, with most participants in the 20-to-34-year group. Extremes of age (≤ 19 and ≥ 35 years) accounted for 16.3% of the cohort with PI ≥ 1.5 were seen in 2 (100%) and 30 (96.78%) respectively. Although no statistic significant value was seen they are known to increase the risk of hypertensive disorders in pregnancy. A majority were multigravida and either overweight or obese. High abnormal uterine artery PI was seen (87.6%), and all these women received aspirin 150 mg prophylactically until 34 weeks (Table 1).

Although not statistically significant, all patients with a history of FGR, hypertension, or a family history of hypertension had abnormal PI. In addition, 5.9% of women had GDM; among them, 83.3% showed abnormal PI, while 16.7% had normal PI (Table 2).

In the association between first trimester uterine artery PI and adverse pregnancy outcomes, women with PI ≥ 1.5 showed higher complication rates. Gestational hypertension was observed in 15 cases (8.4%), while preeclampsia occurred in 9 (5%), including 7 early onset (< 34 weeks) and 2 late onset (> 34 weeks). Impending eclampsia was reported in 3 women (1.7%), HELLP syndrome in 1, and placental abruption in 2 (1.1%). No cases of eclampsia were noted in either group. Regarding fetal outcomes, oligohydramnios was seen in 14 women (7.9%) and FGR in 34 (19.2%), both more frequent in the high PI group. There was one stillbirth (0.6%) in this group. In the postpartum period, hypertension was documented in 6 women (3.4%) with PI ≥ 1.5, comprising 2 cases of gestational hypertension, 3 of preeclampsia, and 1 of HELLP syndrome (Table 3).

Table 1. Distribution of Study Participants According to Various Parameters and association between First-Trimester Uterine Artery Doppler Pulsatility Index (PI) (n = 202)

Parameters	Frequency (n)	Percentage (%)	Normal PI < 1.5, n (%)	High PI ≥ 1.5, n (%)	P-value*
Age (years)	28.60 ± 4.90 (Mean ± SD)				
Age Category					0.20
< 19	2	1.00	0 (0.00)	2(100)	
20-34	169	83.73	24(14.2)	145(85.8)	
> 35	31	15.34	1(3.2)	30(96.8)	
Body Mass Index					0.87
Normal	99	49.00	11 (44)	89(50.3)	
Overweight	70	34.73	11(44)	59(33.3)	
Obese	33	16.33	3 (12)	29(16.4)	
Parity					0.83
Primi-gravida	77	38.11	10 (12.98)	67(87.02)	
Multi-gravida	125	61.88	15(12)	110(88)	
Pulsatility Index (PI)					
Normal PI < 1.5	25	12.38			
Abnormal PI ≥ 1.5	177	87.62			
Aspirin prescription					
No	25	12.38			
Yes	177	87.62			
Mode of delivery					
Vaginal delivery	98	48.51			
Instrumental delivery	1	0.50			
Cesarean section	103	50.99			
Emergency	63	31.19			
Elective	40	19.80			

*P-values were calculated using Pearson Chi-square test. For variables with small expected counts (<5), Fisher's Exact Test was considered. Percentages are row percentages

Out of 202 women, 182 (90%) delivered at term (37 to 40 weeks 6 weeks), while 20 (10%) had preterm births, including one at 28 weeks. Among term deliveries, 162 had PI ≥ 1.5 and 20 had PI < 1.5; in the preterm group, 15 had PI ≥ 1.5 and 5 had PI < 1.5. The predominance of term births may reflect the beneficial effect of aspirin in improving placental perfusion and reducing preterm delivery (Table 4).

Most infants in both PI groups had normal birth weights (2,500 to 3,999 grams). A single case in the PI ≥ 1.5 group involved severe preeclampsia with oligohydramnios and FGR, resulting in a stillbirth at 28 weeks with a birth weight of 800 grams (Table 4).

Table 2. Distribution of study participants according to previous obstetric history, family history, and gestational diabetes in the current pregnancy, with their association to first-trimester uterine artery PI

Variable	n	%	Category	Normal PI < 1.5, n (%)	High PI ≥ 1.5, n (%)	P-value*
Previous history of FGR	7	3.47	No	25(12.8)	170(87.2)	0.60
			Yes	0 (0.0)	7 (100.0)	
Family history of HTN	21	10.40	No	25(13.8)	156 (86.2)	0.81
			Yes	0 (0.0)	21 (100.0)	
History of HTN in previous pregnancy	11	5.45	No	25(13.1)	166 (86.9)	0.60
			Yes	0 (0.0)	11(100.0)	
GDM in Current Pregnancy	12	5.94	No	23(12.1)	167 (87.9)	0.64
			Yes	2 (16.7)	10 (83.3)	

*P-values were calculated using Pearson Chi-square test. For variables with small expected counts (<5), Fisher's Exact Test was considered.

Table 3. Distribution of study participants according to maternal and fetal outcomes and their association with first-trimester uterine artery PI

Outcome	n	%	PI < 1.5 (Normal) n (%)	PI ≥ 1.5 (High) n (%)	P-value*
Maternal Outcomes					
Gestational Hypertension (GHTN)	15	7.40	0 (0.0)	15 (8.5)	0.22
Preeclampsia (PE)	10	4.95	1 (4.0)	9 (5.08)	0.90
Impending eclampsia	4	1.98	1 (4.0)	3 (1.7)	0.41
HELLP syndrome	2	1.00	1 (4.0)	1 (0.6)	0.23
Placental abruption	2	1.00	0 (0.0)	2 (1.1)	0.59
Oligohydramnios	15	7.43	1 (4.0)	14 (7.9)	0.70
Fetal Outcomes					
FGR	38	18.8	4 (16.0)	34(19.20)	0.7
Stillbirth	1	0.50	0 (0.0)	1 (0.6)	1.00
Postpartum Hypertension (GHTN, PE, HELLP)	6	2.97	0 (0)	6 (3.39)	0.10

P-values from Pearson Chi-square test; Fisher's Exact Test used when expected count < 5. Percentages are column percentages (within each PI group)

According to this study, the first-trimester uterine artery Doppler had a sensitivity of 96% and a specificity of 13.6% for predicting pregnancy-related HTN. While the negative predictive value was large (96%), suggesting that women with normal PI were highly unlikely to develop hypertension, the positive predictive value was modest (13.6%), suggesting that the majority of women with abnormal PI did not develop hypertension. This result is further supported by the likelihood ratios, which show helpfulness in ruling out hypertension with a relatively low negative likelihood ratio (0.29) and poor ability to confirm

Table 4. Association between First-Trimester Pulsatility Index (PI) and time of delivery and birth weight (n=202)

Term	PI < 1.5 (frequency %)	PI ≥ 1.5 (frequency %)	P-value
37-38+6	16 (64)	139 (78.53)	0.49
39-40+6	4 (16)	23 (12.99)	
Preterm			0.27
28-33+6	0 (0.00)	3 (1.69)	
34-36+6	5 (20)	12 (6.77)	
Birth Weight			0.94
< 1000 g	0 (0.0)	1 (100)	
1000 – 1499 g	0 (0.0)	2 (100)	
1500 – 2499 g	4 (11.4)	31 (88.6)	
2500 – 3999 g	21 (13.0)	141 (87.0)	
≥ 4000 g	0 (0.0)	2 (100)	
Total	25 (12.4)	177 (87.6)	

Table 5. Diagnostic Accuracy of First-Trimester Uterine Artery PI ≥ 1.5 for Prediction of (HDP) Hypertensive Disorders of Pregnancy (n = 202)

Parameter	Estimate (95% CI) *
Sensitivity	96.0% (80.5–99.3)
Specificity	13.6% (9.3–19.4)
Positive Predictive Value (PPV)	13.6% (9.3–19.4)
Negative Predictive Value (NPV)	96.0% (80.5–99.3)
Positive Likelihood Ratio	1.11 (1.01–1.23)
Negative Likelihood Ratio	0.30 (0.04–2.09)
Area Under Curve (ROC)	0.55 (0.42–0.67)
Prevalence of HDP	12.4%

*Sensitivity, specificity, predictive values, likelihood ratios, and area under ROC curve were calculated using standard diagnostic accuracy formulas. CI= confidence interval. HDP= hypertensive disorders of pregnancy.

disease with a low positive likelihood ratio (1.11). Overall, rather than being a diagnostic test to confirm hypertensive illnesses, uterine artery PI is more effective as a screening technique to rule them out (Table 5).

Although a greater uterine artery PI is linked to a higher prevalence of pregnancy-related hypertension disorders, it has limited specificity and should not be utilized as a stand-alone screening tool. This is because a significant percentage of women with PI ≥ 1.5 did not develop hypertension. These findings suggest that uterine artery PI may be more useful as a risk stratification marker when combined with other clinical and biochemical parameters rather than as an isolated predictor of hypertensive disorders of pregnancy.

An abnormal Doppler study helps in starting aspirin starting from the first trimester which improves placentation and reduces prevalence of the disease and prevents adverse pregnancy outcomes. In our study we can also see that due to intake of aspirin overall complications were less which has decreased maternal and fetal morbidity and mortality.

DISCUSSIONS

Uterine artery Doppler has become a valuable tool to assess uteroplacental circulation from early gestation and has a potential to predict pregnancy complications associated with uteroplacental insufficiency (preeclampsia, FGR, placental abruptio and stillbirth) before the onset of clinical features.[11] This provides opportunity to start medication early and modifies the severity of the disease and careful surveillance is also done to detect the disease early and prevents maternal and fetal complications.[12]

Out of 177 women with high PI values, most of them about 81.9%were between 20 and 34 years old. Most were multigravida (61.9%), while 38.1% were primigravida. This finding aligns with study conducted by Jayson et al. who reported a similar mean age group with raised PI and predominantly were multigravida.[13] Likewise, Paten et al. found that among women with raised PI, most were aged 20 to 35 years, with 37% were nulliparous, 29.6 were primigravida and 33.3% were multigravida.[14]

The study found, most women with raised PI had a normal pre pregnancy BMI (89; 50.3%), and the association was not statistically significant. Similar findings were reported by Parry et al., who also found no significant difference in BMI between groups.[8] Likewise, Elwakel et al. observed no meaningful variation in BMI when comparing women with normal and high PI.[15]

Nearly half of the women delivered vaginally (48.5%), one had an instrumental delivery (0.5%), and just over half underwent cesarean section (51%). Most deliveries (90%) occurred at term, with abnormal PI (≥ 1.5) present in the majority. Among preterm births (10%), three occurred between 28 to 33 weeks 6 days, including one at 28 weeks, while the rest were between 34 to 36 weeks 6 days. Comparable studies reported similar finding by Jayson et al. where almost equal proportions of vaginal (47.1%) and cesarean deliveries (50%), with a slightly higher rate of instrumental births (2.9%).[13] Most of his cohort also delivered at term (85%).[13] Parry et al. noted more vaginal deliveries (62%) compared to cesarean (38%), and reported earlier gestational age at delivery in the high PI group (34.4 ± 2 weeks) compared to the normal PI group (39.9 ± 1.6 weeks).[8]

The 11 women had a history of HTN in a previous pregnancy, all of whom showed raised PI values; 7 developed HTN again during the current pregnancy. Similar study by Beera et al. reported abnormal PI in women with prior preeclampsia.[16] Bramham et al. found recurrence of preeclampsia in 23% of cases, particularly among those who delivered early.[17]

Hernández et al. also noted that the risk of preeclampsia in a second pregnancy was 14.7% if it occurred in the first, rising to 31.9% when present in two prior pregnancies.[18] A history of hypertensive disorders or preeclampsia strongly increases the likelihood of recurrence, and raised PI is commonly observed in these women.

Daughters of preeclamptic mothers are about twice as likely to develop preeclampsia in their own pregnancies. We did observe 21 patients with positive family history of HTN. Beera et al. found that only 1 of 24 women with a family history of preeclampsia (4.2%) developed the condition, compared with 14 of 63 (22.2%) without such a history.[16] Genetic factors appear to play a role, with susceptibility influenced by both maternal and paternal genes.[16]

Among women with diabetes and raised PI (≥ 1.5), three developed GHTN but none developed preeclampsia. In contrast, two diabetic women with normal PI did not develop HTN. Kumar et al. reported that 30.4% of diabetic pregnancies developed preeclampsia, with the risk being more than twice that of non diabetic women.[19] Similarly, Bharadwaj et al. found higher rates of hypertension and preeclampsia in women with gestational diabetes compared to normoglycemic pregnancies (7.8% vs. 5.4%).[20] The risk of developing preeclampsia was more in women with GDM.

Among women with PI ≥ 1.5, maternal complications included gestational hypertension (8.5%), preeclampsia (4.5%), impending eclampsia (1.7%), HELLP syndrome (0.6%), placental abruption (1.1%), and oligohydramnios (7.9%). Fetal outcomes were notable for FGR (19.2%) and one stillbirth (0.6%). Comparable studies reported similar findings. Karpagam et al. observed preeclampsia in 12% and GHTN in 4.3%, emphasizing the role of uterine artery Doppler in screening.[21] Gupta et al. found high PI significantly associated with preterm delivery, FGR, and NICU admission ($p = 0.001$).[22] Jayson et al. also reported adverse outcomes with PI ≥1.5, including gestational hypertension (7.1%), preeclampsia (4.3%), oligohydramnios (14.3%), FGR (20%), and stillbirth (1.4%).[13]

The present study found that first trimester uterine artery Doppler had a sensitivity of 96% and a specificity of 13.6% for predicting pregnancy related hypertension. While the positive predictive value was low (13.6%), meaning most women with abnormal PI did not develop hypertension, the negative predictive value was high (96%), indicating that women with normal PI were very unlikely to develop the condition.

Although a higher uterine artery PI is linked with more hypertensive complications, its low specificity limits its value as a stand alone screening tool, since many women with PI ≥ 1.5 did not develop hypertension. Recent evidence suggests that multiparametric models in the first trimester combining maternal characteristics, uterine artery Doppler, and biochemical markers can markedly improve detection. Using such algorithms, early onset preeclampsia can be identified in over 90% of cases at a 10% false positive rate.[23]

The lack of a significant correlation between elevated uterine artery PI and adverse pregnancy outcomes in this study may be explained by the use of prophylactic low dose aspirin in women with abnormal Doppler findings. Aspirin is known to reduce the incidence of preeclampsia and FGR by enhancing trophoblastic invasion and improving uteroplacental perfusion.[24] As a result, the natural course of placental insufficiency might have been altered and many women did not experience the complications that they would have developed.

The Aspirin for Evidence-Based Preeclampsia Prevention (ASPRE) trial evaluated maternal factors, mean arterial pressure, uterine artery pulsatility index, maternal serum pregnancy-associated plasma protein-A, and placental growth factor. The algorithm was used to screen for preterm preeclampsia between 11 to 13 weeks. It was a randomized double-blind placebo-controlled study which showed aspirin group had a 62% lower incidence of preterm preeclampsia than the placebo group.[25]

However, this study does have some limitations. The sample size was small that can limit the statistical power of the study. It was a single centered study. Results from long-term follow-up for newborns were not evaluated.

CONCLUSION

Uterine artery Doppler in the first trimester is a very helpful, dependable, and noninvasive method to assess uteroplacental perfusion and predict problems later in pregnancy. It helps in identifying high risk pregnancies that requires closer surveillance. This helps us to start prophylactic aspirin therapy, which helps to change the severity and timing onset of disease. The incidence of maternal and neonatal morbidity and mortality can be reduced by implementing Doppler ultrasound as a standard prenatal care protocol in the first trimester. According to our study also, it appears to be useful in preventing HTN and its subsequent problems. Doppler predicted the risk and aspirin prevented the disease.

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