“PREDICTING PRE-ECLAMPSIA & INTRAUTERINE GROWTH RESTRICTION THROUGH TRIMESTER BY USING UTERINE ARTERY DOPPLER ULTRASOUND”

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Abstract

Assessment of Multiple parameters is the best indicator for prediction of Pre-eclampsia and fetal growth restriction. Increased impedance to uterine artery flow in both high risk and low risk pregnancies is associated with the risk for subsequent development of Pre-eclampsia and fetal growth restriction which intern serves as a better predictor for high-risk patients. A study was undertaken to examine the value of uterine artery Doppler at 18–24 weeks of gestation in the identification of women at risk of developing pre-eclampsia and fetal growth restriction. The Present Study was conducted in Government General Hospital, Kurnool where in 200 singleton pregnant women were taken for the assessment of OPD. 57.5% women enrolled in the study were primigravida, 42.83% women were multigravida. At the outset during initial screening by Doppler ultrasound of both uterine arteries at 18 to 20 weeks, 79% women had a normal Doppler study and 21% women had an abnormal Doppler study. Out of 21 patients with a persistent abnormality on Doppler at 24 weeks, 5 had a unilateral notching, 8 with bilateral notching and 8 patients had increased indices only. In the present investigation 158 patients (79%) had a normal during screening. 58.86% were primigravidae and 40.47% were multigravidae. Out of these patients 3.1% developed PIH, 3.79% developed IUGR respectively. 93.03% had a normal outcome of pregnancy, 77.84% of women with normal Doppler delivered vaginally, 22.15% delivered by caesarean section. 94.3% women delivered babies with good Apgar score. Uterine artery Doppler may be included in hospitals with facilities and infrastructure to identify a group of patients at risk of developing Pre-eclampsia or fetal growth restriction. Further studies have to be explored for examining its potential as a screening tool.

Keywords: Pre-eclampsia, fetal growth, Doppler, IUGR.

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INTRODUCTION

Hypertensive disorders remain among the most significant and intriguing unsolved problems in obstetrics. In developing countries they rank second only to anemia complicating approximately 7 to 10 percent of all pregnancies.[1] Preeclampsia is identified in 3.9 percent of all pregnancies. According to the World Health Organization reviewed maternal mortality worldwide and estimated that in the world, 14 percent of maternal deaths were due to hypertensive disorders [2]. Perinatal and infant mortality are a significant cause of concern in developing countries. Preeclampsia and intrauterine growth restriction are important causes of perinatal and maternal morbidity and mortality. The incidence of intrauterine growth restriction is 3 to 10% [3]. Commonest cause of IUGR is placental insufficiency. Other important causes are poor maternal nutrition, social deprivation; viral infections. IUGR babies are prone to complications like birth asphyxia, meconium aspiration and neonatal hypoglycemia, hypothermia, fetal demise. This is true for term and preterm growth-restricted infants [4, 5, 6]. Preeclampsia is characterized by an imbalance between prostacycline and thromboxane production [7], as well as failure of the second wave trophoblastic invasion of endometrio-myometrial vasculature. The result is abnormal uteroplacental blood flow, and this has lead to the idea of using Doppler assessment of uterine artery velocity waveforms as a method of screening for this antenatal complication [8]. Uterine Doppler testing is noninvasive and technically easy with no additional cost when integrated into routine ultrasound examination. Screening for preeclampsia at an early gestational age may allow vigilant antenatal surveillance and appropriate timing of delivery in order to avoid serious maternal sequel. Various hemodynamic and biochemical measures have limited accuracy as screening measures for this condition [9, 10]. The largest systematic review judging the utility of uterine artery Doppler assessment was published11. Their analysis showed that an abnormal velocity waveform with or without a diastolic notch carried a likelihood ratio of 6.4 for the development of preeclampsia and 3.6 for development of fetal growth restriction [11]. Abnormal uterine artery Doppler studies in both the first and second trimesters have been shown to be associated with subsequent perinatal complications. Hence, there is a necessity to study the role of uterine artery velocimetry in predicting preeclampsia and Intrauterine growth restriction. Attempts were made to assess the role of Doppler ultrasound of uterine arteries in antenatal women in prediction of preeclampsia, intrauterine growth restriction. Secondly to compare Doppler Ultrasound findings to maternal and fetal outcome. Measurement in early pregnancy of a
variety of biological, biochemical and biophysical markers implicated in the pathophysiology of preeclampsia have been proposed to predict its development. Attempts were done to identify early markers of faulty placentation, reduced placental perfusion, endothelial cell activation and dysfunction. Sensitivities of the three tests namely roll over, Isometric exercise, and Angiotensin II infusion test ranges from 55 to 70 percent with specificities of approximately 85 percent. Preeclampsia is best described as a pregnancy specific syndrome that can affect virtually every organ system. The other incidence is markedly influenced by race, ethnicity and thus by genetic predisposition. Other factors include environmental, socioeconomic and seasonal influences. Considering these vicissitudes, a number of worldwide studies were reviewed, the incidence of preeclampsia in nulliparous populations ranging from 3 to 10 percent. The incidence of preeclampsia in multiparous is also variable but is less than that for nulliparous. Etio-pathogenesis were also studied as a preeclampsia account for the observation of gestational hypertensive disorders. Regardless of precipitating etiology, the cascade of events that lead to the preeclampsia syndrome is characterized by based on abnormalities that result in vascular endothelial damage and subsequent vasospasm, transudation of plasma, ischemic and thrombotic sequelae. Following is a systematic flow of the preeclampsia syndrome (Figure 1).

Fig.1: Stage wise flow of placental progression leading to Preclampsia syndrome.

In normal implantation the uterine spiral arterioles undergo extensive remodeling as they are invaded by endovascular trophoblasts. These cells replace the vascular endothelial and muscular linings to enlarge the vessel diameter. The veins are invaded only superficially. In preeclampsia, however, there may be incomplete trophoblastic invasion. With such shallow invasion, decidual vessels, but not myometrial vessels, become lined with endovascular trophoblasts. Associates showed that the magnitude of defective trophoblastic invasion of the spiral arteries correlates with the severity of the hypertensive disorder.
Using electron microscopy arteries taken from the implantation site were examined. They reported that early preeclampsia changes included endothelial damage, insulation of plasma constituents into vessel wall, proliferation of myointimal cells, and medial necrosis. Lipid accumulated first in myointimal cells and then within macrophages. Such lipid laden cells and associated findings were referred as atherosis. Thus, it is likely that the abnormally narrow spiral arteriolar lumen impairs placental blood flow. Although the cause of preeclampsia still remains unknown, evidence for its manifestation begins early in pregnancy with covert pathophysiological changes that gain momentum across gestation and eventually become clinically apparent. (Figure -2)

Fig.2: Showing the difference between the Normal and Preeclampsia condition.

Attempts were made to assess uterine, fetal growth rate intervillous and placental blood flow has been hampered by several obstacles like inaccessibility of the placenta. Several disturbances in fetal metabolism have been implicated in abnormal fetal growth. Earlier researchers found that the major cause of hypoglycemia in SGA fetuses was reduced supply rather than increased fetal consumption or diminished fetal glucose production. These infants had hypoinsulinemia along with hypoglycemia. The degree of fetal growth restriction did not correlate with plasma insulin levels, suggesting that glycaemia is not the primary determinant of poor fetal growth. Temperature instability and renal failure. To occur as a result of the alteration of normal fetal physiology in utero.
Fig.3: The first Doppler ultrasound machine

Development of Colour Doppler ultrasonography: Spectral Doppler ultrasound interrogates along the single line of ultrasound beam transmission. The hemodynamic information thus generated is limited to unidirectional flow velocity characterization from the target area. The development of real time two dimensional colour Doppler ultrasonography therefore represents a major technologic break through. It was first to characterize the Doppler waves from the ovarian and uterine arterial circulations utilizing pulse duplex Doppler instrumentation [12] (Figure 3).

Fig.4: A-continuous wave Doppler, B-Pulsed wave Doppler.
In the current and more sophisticated color Doppler imaging (CDI) color-coded pulse Doppler information is super imposed on B mode ultrasonic image (Figure 4). In this method, Colour is assigned to flow direction. Customarily, flow towards the Doppler transducers is displayed in red, and flow away from it shown in blue. The structures that do not move are represented in basic gray scale image.

The blood flow characteristic can be quantified by various Doppler indices like the systolic/diastolic ratio (S/D), resistance index (RI) and the pulsatility index (PI), which can be taken on any vessel (Figure 5). [13,14]
Fig. 5: Blood Flow Characteristics of the Doppler indices

A - Peak systolic velocity  
B - End diastolic velocity  
C - Early diastolic velocity  
M - Mean velocity

The indices are:

\[ \frac{\text{Peak systolic velocity}}{\text{End Diastolic Velocity}} = \frac{A}{B} \]

Resistance Index (RI) i.e.,

\[ \frac{\text{Peak systolic velocity} - \text{End Diastolic Velocity}}{\text{Peak Systolic Velocity}} = \frac{A-B}{A} \]

Pulsatility index (PI) i.e.,

\[ \frac{\text{Peak systolic velocity} - \text{End Diastolic Velocity}}{\text{Mean Diastolic Velocity}} = \frac{A-B}{M} \]

S/D ratio gives a simple evaluation of blood flow during diastole and provides estimation of downstream resistance [17].

The pulsatility index considers the mean velocity as denominator, that is the whole of the flow is given consideration not just the diastolic flow and hence can be used to analyze data from various vessels without encountering the excessive variation that can be caused by division by small numbers as with the other two indices.

Table 1: Major Sources of Doppler Imaging Artifacts

<table>
<thead>
<tr>
<th>Doppler Frequency: Higher frequencies lead to more tissue attenuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Spectral Broadening: Excessive system gain or changes in dynamic range of the gray scale display. Sample volume too near the vessel wall</td>
</tr>
<tr>
<td>Increase in Aliasing: Decrease in pulse repetition frequency. Decrease Doppler angle. Higher Doppler frequency transducer.</td>
</tr>
<tr>
<td>Doppler Angle: Relatively inaccurate above 600</td>
</tr>
<tr>
<td>Sample Volume: Large sample volumes increase the vessel wall noise.</td>
</tr>
</tbody>
</table>
In the first half of pregnancy, trophoblasts invade the uterine vessels and result in dilated spiral arteries, which increase the uterine perfusion 10 to 12 fold. These arteries provide nutrient supply and gas exchange for the fetus. Each uterine artery should be identified soon after the crossing of the iliac vessels (Figure 6).

**Normal Uterine artery waveform in first and second trimester**

Based on the results of his study, Bower had assessed the value of incorporating Doppler ultrasound of the uterine arteries into routine ultrasound in unselected population. It was a multicentre cross sectional study, 2430 women were scanned. The results demonstrate higher sensitivities than previous studies, but with a high proportion of false positive tests. By including an early diastolic notch in the definition of an abnormal FVW the prediction of pre-eclampsia is markedly improved. Their study emphasized the benefit of identifying group of women predisposed for complications for further assessment and possible intervention.

A study tried to determine the optimal method of measuring uterine artery waveforms during screening [18]. They concluded that the best screening test for preeclampsia and SGA infants was the placental-side uterine artery RI or AC ratio above the 90th percentile for gestational age when the placenta was located on the left or right, and the highest RI or AC ratio when the placenta was midline. This method identified 51% of women with subsequent preeclampsia or SGA infants and had a positive predictive value of 29%.

The value of transvaginal Uterine artery Doppler in screening was studied [19]. The study conducted was a large multi centre screening by transvaginal uterine artery Doppler was done at 23 weeks of gestation. The sensitivity of bilateral notches in predicting pre-eclampsia and/or fetal growth restriction was similar to that of increased pulsatility index but the screen-positive rate with notches (9.3%) was much higher than that with increased pulsatility index (5.1%). They concluded that a one-stage color Doppler screening program at 23 weeks identifies most women...
who subsequently develop severe pre-eclampsia and/or fetal growth restriction. Studies were conducted wherein maternal history was combined with Doppler ultrasound in screening for preeclampsia.

In 1987 examined 60 women who had essential hypertension or renal disease or a previous pregnancy complicated by pregnancy-induced hypertension [20]. They measured impedance to flow in the arcuate arteries at 18–20 weeks of gestation and defined as an abnormal result a resistance index of more than 0.57. They reported that this test identified 64% of pregnancies that subsequently developed pregnancy-induced hypertension.

Table 2: Prediction of preeclampsia

<table>
<thead>
<tr>
<th>No. of cases (n)</th>
<th>Gestation age at screening (wks)</th>
<th>Prevalence of Preeclampsia (%)</th>
<th>Sensitivity (%)</th>
<th>Specificity(%)</th>
<th>PPV(%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>18-20</td>
<td>37</td>
<td>64</td>
<td>94</td>
<td>70</td>
<td>80</td>
</tr>
</tbody>
</table>

In a similar study, [21] examined 91 women who had chronic hypertension, history of pre-eclampsia or fetal loss and a variety of other medical conditions. They measured impedance to flow in the arcuate arteries at 24 weeks of gestation and defined as an abnormal result a resistance index of more than 0.57.

The studies were in Doppler waveform in 343 pregnant women [22]. Results from 323 patients were available for analysis. They grouped the patients into high risk and low risk based on history and co morbid medical disorders. 175 women were included in the group at high risk for hypertensive disorders of pregnancy or intrauterine growth restriction. They measured impedance to flow in the uterine arteries at 21–24 weeks of gestation and defined an abnormal result by a resistance. The control group which was considered as a low risk group comprised data of 172 patients. The sensitivity of increased impedance in the prediction of PIH/IUGR was 56%. Individually neither notch nor RI could predict PIH effectively in low risk and high risk group. Abnormal Doppler could predict IUGR with or without PIH better.

Several studies in unselected populations have examined the value of Doppler assessment of the uteroplacental circulation in the prediction of pre-eclampsia and/or intrauterine growth restriction. The early studies were limited by the use of continuous wave Doppler, which is a blind investigation. However, recent studies have used color Doppler ultrasound to assess flow in the
uterine artery at the point where it crosses the external iliac artery, which is a more reproducible examination. Discrepant results between the studies may be the consequence of differences in Doppler technique for sampling and the definition of abnormal flow velocity waveform, differences in the populations examined, the gestational age at which women were studied, and different criteria for the diagnosis of pre-eclampsia and intrauterine growth restriction.

**Single stage screening:**

The studies with the role of a one stop Doppler at 20 weeks along with an anomaly scan [23]. They studied 1022 unselected women who were subjected to a Doppler study of the uterine artery at 19 to 21 weeks of gestation. Presence of a diastolic notch or RI>95th centile was an abnormal Doppler. Results from 946 women were available for analysis. 216 (22.8%) women had an abnormal Doppler study. 77% women had Normal Doppler pattern.

While the positive predictive value of bilateral notching at 20 weeks gestation for any complication is encouraging, it is lower than with a two stage screening method. Although Doppler imaging has its limitation when used as a single stage procedure, this study concluded it to be one of the most effective methods to date for identifying high and low risk population in the second trimester.

The scientists attempted to correlate the persistence of uterine artery notching at 24 weeks of gestation with the development of preeclampsia, IUGR. 53 women were included in the study [24]. Of these, 38 were primigravidae and formed one group. The second group comprised 15 patients with risk factors like previous history of PIH, IUGR, and IUD. Doppler uterine artery evaluation was done at 24 weeks of gestation and presence of a unilateral or bilateral notching was considered as an abnormal Doppler.

The investigators compared the uterine artery Doppler velocity and impedance indices in the presence and absence of diastolic notch, in the prediction of PIH, IUGR in high risk women [25]. Data from 157 women scanned at a median of 24 weeks (23-26 weeks) were analyzed. 40% of the study population were primigravidae. 50 women developed adverse outcomes.

40 women were found to have bilateral uterine artery notching. They observed that the best screening performance in this population, irrespective of notch status was achieved using mean PI or RI.

The study with doppler waveforms of the uterine artery in 52 women with singleton pregnancies in between 19 to 26 weeks of gestation [26]. Women with history of hypertension, preeclampsia,
intrauterine growth restriction, Abruptio placenta, intrauterine death were included in the study. Mean maternal age was 32.8 (23-46 yrs.). 2 women were primigravida and 50 women were multigravida. Mean birth weight was 2.9 kg.

They showed that Doppler uterine artery is a useful method in the prediction of complications. Patients with bilateral notching or RI>0.7 at 24 weeks of gestation represent a risk group for adverse pregnancy outcome.

The Study Doppler waveform of uterine artery in 179 antenatal women at 24 to 26 weeks [27]. Any notch in uterine artery, unilateral or bilateral, or RI>0.6 was considered as abnormal. Women were categorized into two groups based on presence or absence of risk factors (history of hypertension, diabetes, obesity, age; past history of preeclampsia, IUGR, family history of preeclampsia, IUGR). 52 (29.05%) and 127 (70.95%) women were in the High risk and Low risk groups respectively.

Mean birth weight in HR women was 2.25 kg and in low risk women was 2.9 kg. In their study, an abnormal uterine artery flow was associated with an increased relative risk of preeclampsia in both High and Low risk women. The sensitivity and specificity of uterine artery Doppler was high in both groups.

**Two stage screening:**

The examination of the uterine arteries in 200 primigravida by Doppler ultrasound at 18 to 20 weeks of gestation and, in those with increased impedance (resistance index greater than 0.58), the Doppler studies were repeated at 24 weeks

Out of the 75 women with abnormal Doppler at 18 to 20 weeks, 16 (21%) demonstrated bilateral abnormality and 59 (79%) on one side only. RI>0.58 (increased impedance at 24 weeks) was found in 21 cases.

The results of this study indicate that most cases of severe preeclampsia associated with IUGR can be detected by Doppler screening in early pregnancy. [28] examined the uterine arteries in 2430 unselected women by continuous wave Doppler at 18 to 22 weeks of gestation. An abnormal Doppler was defined as RI above 95th centile or the presence of a diastolic notch in either uterine artery.

In those with increased impedance to flow (resistance index greater than the 95th centile or early diastolic notch in either of the two uterine arteries), the Doppler studies were repeated by color Doppler at 24 weeks. Persistently increased impedance was observed in 5.4% of the patients (compared to 16% at 20 weeks). It was reported that increased impedance provides good
prediction of pre-eclampsia (but not of non-proteinuric pregnancy-induced hypertension). Furthermore, in terms of low birth weight, abnormal waveforms provide better prediction of severe (below the 3rd centile) rather than mild (below the 10th centile) intrauterine growth restriction.

The researchers examined the uterine arteries in 1233 unselected women by continuous wave Doppler at 20 weeks of gestation [29]. In those with increased impedance (resistance index greater than the 95th centile or early diastolic notch in either of the uterine arteries), the Doppler studies were repeated by color Doppler at 24 weeks. Persistently increased impedance was observed in 8.9% of the patients. The sensitivity of the test for pre-eclampsia was 77%, and for intrauterine growth restriction it was 32%. Bilateral notching at 24 weeks was observed in 3.9% of patients; the sensitivity for pre-eclampsia was 55%, and for intrauterine growth restriction it was 22%. The respective sensitivities for those complications leading to delivery before 35 weeks were 81% and 58%. Of the 110 women with an abnormal Doppler at 24 weeks, 62 women had unilateral notching and 48 had bilateral notching.

MATERIALS AND METHODS
A study was conducted from August 2012 to August 2014. Data for the study is collected from patients attending Antenatal Outpatient department of Obstetrics and Gynecology, Government General Hospital, Kurnool Medical College, Kurnool. Study design: A prospective clinical study of 200 singleton pregnant women were undertaken to evaluate the role of Doppler ultrasound of uterine arteries in prediction of pre-eclampsia, intrauterine growth restriction.

Inclusion criteria
Antenatal women with singleton pregnancy of gestational age 18 to 20 wks. attending antenatal outpatient department.

Exclusion criteria
1. Chronic hypertension
2. Preexisting renal disease
3. Essential hypertension
4. Diabetes
5. Multiple pregnancy
6. Congenital abnormalities
The present investigation was performed in Antenatal women attending the outpatient department who enrolled at 18 to 20 weeks of gestation. Initially routine scan is performed using 2-D real time ultrasound with 3 to 5 MHZ convex sector transducer. The Machine used is ESAOTE MEGAS GPX. Doppler wave form was obtained after localizing the uterine artery by B-mode real time scanner. Pulsed Doppler was used to get Doppler signals after localizing the vessels. Resistance index, Pulsatility index, presence of early diastolic noted are noted.

Patients with an abnormal Doppler waveform are called for a second assessment at 24 weeks and the persistence of abnormal waveform is noted. All the patients enrolled in the study were followed till at the time delivery and observed for the development of Preeclampsia and Intrauterine growth restriction, mode of delivery and neonatal outcome.

**Statistical Analysis**

Doppler ultrasound results were compared with maternal and fetal outcome by using statistical and analytical tests like odds ratio, confidence interval, chi square test and predictive tests with the help of powerful tool origin 7.0.

**RESULTS AND DISCUSSION**

The present study was conducted in the department of Obstetrics and Gynecology, Government General Hospital, Kurnool Medical College, Kurnool. In this prospective study, 200 singleton pregnant patients are enrolled at 18 to 20 weeks of gestation.

Out of 200 patients who underwent Doppler ultrasound, 42 had an abnormal Doppler study at first stage of screening and were called for a second assessment at 24 weeks. 25 patients had a persistent abnormality at 24 weeks. A total of 29 patients developed preeclampsia and 10 patients developed intrauterine growth restriction. Out of the 200 women screened, women aged 21 to 25 yrs. formed the larger group comprising 121 women. In the study population, primigravida are more in number than multigravida, 57.5% vs. 42.5%.

<table>
<thead>
<tr>
<th>Age</th>
<th>&lt;20yrs</th>
<th>21-25yrs</th>
<th>26-35yrs</th>
<th>&gt;35 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=200</td>
<td>41</td>
<td>121</td>
<td>38</td>
<td>0</td>
</tr>
</tbody>
</table>

**Mean age of patients in the study:** 22.9yrs

A total number of 200 women with singleton pregnancies were screened at 18 to 20 weeks of gestation with Doppler ultrasound of both uterine arteries. 158 women (79%) had a normal Doppler study. 42 women (21%) had an abnormality either the presence of a diastolic notch or increased velocity indices. These women were requested to come for a reassessment after 4 weeks at 24 weeks of gestation.

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42 women with an initial abnormal Doppler at 18 to 20 weeks are called for a repeat Doppler at 24 weeks. At the second stage of screening, 25 women (59.52%) had persistence of abnormality in the Doppler waveform whereas 17 women (40.48%) had a normal Doppler at second stage of screening.

**Table 6: Doppler ultrasound results at 24 weeks**

<table>
<thead>
<tr>
<th>Doppler at 24 weeks</th>
<th>No. Of cases(n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>17(40.48%)</td>
</tr>
<tr>
<td>Abnormal</td>
<td>25(59.52%)</td>
</tr>
</tbody>
</table>

**Table 7: Doppler waveform abnormality in study**

<table>
<thead>
<tr>
<th>Duration</th>
<th>U/L Notch only</th>
<th>B/L Notch only</th>
<th>U/L Notch with RI,PI&gt;95th centile</th>
<th>B/L Notch with RI,PI&gt; 95th centile</th>
<th>RI,PI&gt;95th centile only</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 to 20 weeks</td>
<td>3(7.14%)</td>
<td>3(7.14%)</td>
<td>8(19.04%)</td>
<td>10(23.81%)</td>
<td>18(42.86%)</td>
<td>42</td>
</tr>
<tr>
<td>24 weeks</td>
<td>1(4%)</td>
<td>Nil</td>
<td>5(20%)</td>
<td>8(32%)</td>
<td>11(44%)</td>
<td>25</td>
</tr>
</tbody>
</table>

At 18 to 20 weeks, 18 women (42.86%) had only increased velocity indices, 10 women (23.81%) and 8 women (19.04%) had bilateral, unilateral notching with increased indices respectively. Notching without abnormal indices was noted in 6 patients (14.28%). Among the 25 patients with persistent abnormality of Doppler at 24 weeks, 11 patients (44%) had persistent increased velocity indices. 8 patients (32%) had bilateral notching with an increased resistance and pulsatility index. Increased velocity indices persisted in 44% of patients at the second stage of screening in comparison with patients who had a diastolic notch at initial screening.

**Fig.7: Abnormal Doppler at 18 to 20 weeks and 24 weeks**
In this study population of 200 patients, 29 patients (14.5%) and 10 patients (5%) developed PIH, IUGR respectively. 80% of the study population had a normal pregnancy outcome.

### Table 8: Age distribution in relation with Doppler results

<table>
<thead>
<tr>
<th></th>
<th>&lt;20 years(n=41)</th>
<th>21-25 yrs(n=121)</th>
<th>26-35 yrs(n=38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Doppler</td>
<td>34(82.93%)</td>
<td>96(79.34%)</td>
<td>28(73.68%)</td>
</tr>
<tr>
<td>Abnormal Doppler at</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>first visit</td>
<td>7(17.07%)</td>
<td>25(20.66%)</td>
<td>10(26.31%)</td>
</tr>
<tr>
<td>Persistent abnormal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doppler at 24 wks</td>
<td>4(9.7%)</td>
<td>14(11.57%)</td>
<td>7(18.42%)</td>
</tr>
</tbody>
</table>

Abnormal Doppler was noted in 26.3%, 17.07% of women in the age group of 26 to 35 yrs. and younger than 20 yrs. respectively. There was a persistence of abnormality at second stage of screening in 18.42% among women aged 26 to 35 yrs. and in 9.7% of women less than 20 years of age. Majority (79.34%) of women of age group 21 to 25 had a normal Doppler study. Pregnant Women in extremes of age are more likely to have a complication of their pregnancy outcome. Abnormal Doppler at initial screening was more in primigravida (54.76%) than in multigravida (45.23%). Persistence of the abnormality in Doppler at 24 weeks is more significant in primigravida than multigravida as primes are more likely to develop hypertensive disorders, multigravida may have underlying metabolic abnormality that predisposes to preeclampsia.

### Fig.8: Age distribution in women with PIH

The prevalence of PIH in the study population was 14.5%. Most women (65.5%) who developed PIH were aged in between 21 to 25 yrs. 6 women (20.69%) and 4 women (13.79%) in the age groups of 26 to 35 yrs., less than 20 yrs. respectively developed PIH. Majority of women who developed preeclampsia were primigravidae (62.06%). 37.92% of multigravida women developed preeclampsia. Primigravida constitute a high risk group in the development of preeclampsia.
A total of 29 patients who developed PIH, 24 women (82.75%) had an initial screening abnormality and 72.41% had a persistent abnormality at second stage of screening. 5 patients (17.245) had an initial normal screening and yet developed PIH.

Table 9: Abnormal Doppler study results in cases with PIH

<table>
<thead>
<tr>
<th></th>
<th>U/L notch only</th>
<th>B/L notch only</th>
<th>U/L notch with RI,PI&gt;95th centile</th>
<th>B/L notch with RI,PI&gt;95th centile</th>
<th>RI,PI&gt;95th centile only</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cases</td>
<td>Nil</td>
<td>Nil</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>(18 to 20 weeks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. Of cases</td>
<td>Nil</td>
<td>Nil</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>(24 weeks)</td>
<td></td>
<td></td>
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</tbody>
</table>

From the above Table No., it is evident that either unilateral or a bilateral notch in the uterine artery has no significance. Women with an abnormal RI, PI alone or notching and an abnormal RI,PI are more likely to develop PIH and they are to be followed up carefully.

Among the 29 patients who developed PIH, 13 patients (44.82%) developed mild PIH and 16 patients (55.17%) developed severe PIH. Of the women who had an initial normal Doppler at first screening, 4 (28.57%) developed mild PIH and 1 patient developed severe preeclampsia.

15 patients (93.75%) who had severe preeclampsia were noted to have an abnormal Doppler at initial screening and 9 patients (69.23%) with mild PIH had an abnormal Doppler at initial assessment. Therefore an abnormal Doppler study at 18 to 20 weeks significantly predicts the development of severe and mild preeclampsia.

Fig. 9: Abnormal Doppler in women with PIH
8 patients (57.14%) with persistent bilateral notching of uterine artery with an increased RI, PI had severe preeclampsia. Among women with an increased RI, PI at 24 weeks of gestation, 33.33% and 30% developed severe and mild preeclampsia respectively. Bilateral notching of uterine arteries with an increased RI, PI is highly predictive of severe preeclampsia. Increased RI, PI though predictive of preeclampsia are not very significant with respect to severity. Out of 5 patients, 4 patients (13.79%) had mild PIH and one patient (3.5%) had severe PIH.

6 women (20.68%) had IUGR in association with PIH. Of them, 5 patients had a persistent abnormal Doppler at 24 weeks. Presence of notch in both the uterine arteries with an increased RI, PI is significantly associated with IUGR and Preeclampsia.

The mode of delivery through vagina was found to be 4 (13.79%) were induced preterm deliveries, 3 were induced for severe preeclampsia and 1 induction was for Eclampsia. There were a total of 25 term deliveries, among which 7 women had a spontaneous vaginal delivery. 9 women had an induced vaginal delivery. 5 of the induced vaginal deliveries were for preeclampsia and the other 4 were for PROM and prolonged pregnancy. 9 patients underwent emergency caesarean section. Indications for caesarean sections being severe preeclampsia in 3 women, Eclampsia with CPD in 1 woman. Rest of the caesarean sections were indicated for fetal distress (2), Bad obstetric history (1), CPD (2).

Primigravidae constituted most patients with mild and severe PIH. 88.88% of primigravida who developed severe PIH and 66.66% of primigravidae who developed mild PIH had an abnormal Doppler at 18 to 20 weeks. 7 multigravida had severe PIH and 4 of them had mild PIH. Among the multigravida, 100% abnormal Doppler was associated with severe PIH.

Abnormal Doppler at initial screening identified most primigravidae and all multigravidae who later developed severe preeclampsia.

A persistently abnormal Doppler correlated well with severe preeclampsia. Presence of bilateral notching with increased RI, PI in primi and multigravida was associated with the development of severe preeclampsia in most of the cases.

At the time of second screening, 8 patients (80%) who had a normal Doppler subsequently developed IUGR. This may be explained by the fact that Doppler may identify those cases that are likely to develop IUGR because of uteroplacental insufficiency which is one of the many causes for IUGR. Therefore, among all the patients who developed IUGR, only 2 (20%) had an abnormal Doppler.
Fig. 10: Age distribution in IUGR

Most patients who developed IUGR were in the age group of 21 to 25 and younger than 20 yrs. 50% cases of IUGR were primigravidae. Second gravidae and multigravida constituted the rest of cases. Out of 200 cases, there were 158 cases that had a normal Doppler screening initially. Of these, 3.1% developed PIH, IUGR was seen in 6% and the remaining 140 patients (93.03%) had a normal pregnancy outcome. Most of the babies delivered in the group of patients who had a normal Doppler had a good Apgar score. NICU admissions were noted in patients with prolonged pregnancy.

Table 10: Single or bilateral abnormal uterine artery flow waveforms in prediction

<table>
<thead>
<tr>
<th>Outcome</th>
<th>N</th>
<th>True positive</th>
<th>False negative</th>
<th>False positive</th>
<th>True negative</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preeclampsia</td>
<td>29</td>
<td>21</td>
<td>5</td>
<td>18</td>
<td>155</td>
<td>80.7</td>
<td>89.59</td>
<td>53.84</td>
<td>96.87</td>
<td>16.55</td>
</tr>
<tr>
<td>IUGR</td>
<td>10</td>
<td>2</td>
<td>6</td>
<td>38</td>
<td>145</td>
<td>25</td>
<td>79.23</td>
<td>5</td>
<td>96</td>
<td>1.25</td>
</tr>
<tr>
<td>NICU</td>
<td>20</td>
<td>10</td>
<td>8</td>
<td>31</td>
<td>150</td>
<td>55.5</td>
<td>82.87</td>
<td>24.39</td>
<td>94.93</td>
<td>4.702</td>
</tr>
</tbody>
</table>

Table 11: Prediction of the outcome for pregnancies with normal uterine artery Doppler studies compared with pregnancies found to have a persistent notching of uterine artery waveform

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Normal (n=158)</th>
<th>Abnormal(n=42)</th>
<th>Odds Ratio</th>
<th>CI (95%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Preeclampsia</td>
<td>5</td>
<td>3.16</td>
<td>22</td>
<td>52.38</td>
<td>33.66</td>
</tr>
<tr>
<td>IUGR</td>
<td>6</td>
<td>37.97</td>
<td>2</td>
<td>4.76</td>
<td>1.266</td>
</tr>
<tr>
<td>NICU</td>
<td>8</td>
<td>5.06</td>
<td>10</td>
<td>23.8</td>
<td>5.8594</td>
</tr>
</tbody>
</table>

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DISCUSSION

The exact etiology of preeclampsia remains unknown. Several theories have been proposed over the years, most of which have not withstood the test of time. Preeclampsia contributes significantly to maternal and fetal morbidity. A number of methods have been attempted in its prediction. A number of studies have been conducted in the search for an ideal screening test in prediction of preeclampsia, IUGR. Though there are several methods that are used in predicting preeclampsia, no single method has found to be the best. This study has attempted to correlate Doppler ultrasonography as a test for prediction of preeclampsia with maternal outcome. Mean age of this study population is in accordance with the women in reproductive age group in India. The difference in mean age in comparison with the above study may be due to the consideration of risk factors in maternal history prior to recruitment in their study. Majority of women in this study were in the range of 21-24 yrs. similar to the above study. Present study had more women who were primigravidae than multigravidae as in the study [27]. The rest of the studies had more number of multigravidae probably because they had recruited patients with a preference for the presence of risk factors like previous history of PIH, IUGR etc Normal Doppler study was seen in 79% of patients at first stage screening which was comparable with that of the percentage was noted to be lesser in the study as the study was conducted at 24 weeks of gestation and in the study as they had recruited only high risk patients in their study. 42 patients (21%) had an abnormal Doppler study at 18 to 20 weeks of gestation in the present study which is comparable initial product with that of other researchers. The percentage of study population with a persistent abnormality of Doppler ultrasound at 24 weeks in this study is comparable with that of other study [19] The percentage of women with an abnormal Doppler at 24 weeks was more in the study [24] as most of the recruited women were at risk population. The incidence of PIH in our study population is 14.5% which is comparable with the studies conducted by [22,27]. The low incidence in studies conducted by [23], the study deals with markets probably because of the

Table 12: Predictive value of persistent unilateral and bilateral notching of the uterine artery Doppler at 24 weeks in development of PIH

<table>
<thead>
<tr>
<th>At 24 weeks</th>
<th>True positive</th>
<th>False negative</th>
<th>True negative</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U/L Notch</td>
<td>5</td>
<td>24</td>
<td>6</td>
<td>189</td>
<td>17.24</td>
<td>96.92</td>
<td>45.45</td>
</tr>
<tr>
<td>B/L notch</td>
<td>8</td>
<td>21</td>
<td>5</td>
<td>187</td>
<td>27.59</td>
<td>97.4</td>
<td>61.54</td>
</tr>
</tbody>
</table>

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August Issue 121
study being conducted in developed countries and the relatively higher incidence in the study conducted [24] may be due to inclusion of women with risk factors in their study. The prediction of preeclampsia by the presence of unilateral uterine artery notching had a high specificity (96.92%) comparable to the study but the negative predictive value was observed to be lower than that of other study. However the presence of bilateral notching though is noted to have a high specificity, the negative predictive value is a bit lower. The sensitivity and positive predictive value was higher with bilateral notching than that of unilateral notching. The prediction of preeclampsia by an abnormal velocity indices were noted to have a sensitivity comparable to [20], specificity in accordance with [22], positive predictive value and negative predictive value similar to that of other prediction. The sensitivity of prediction of preeclampsia by the presence of notch and increased velocity indices is comparable to the study. The positive predictive value of the present study is similar to that by Harrington et al. The negative predictive value is observed to be comparable with the studies [29]. The prediction of preeclampsia by the presence of any Doppler abnormality was comparable to the studies by other researchers. The present study had a higher positive predictive value. The sensitivity and specificity was similar to the study. The negative predictive value in the prediction of IUGR was comparable with other group [26]. The present study had a low sensitivity and positive predictive value.

**CONCLUSION**

This study shows a significant association between persistent abnormal Doppler study of uterine arteries at 24 weeks gestation and the development of Preeclampsia. The severity of preeclampsia is more in women with abnormal Doppler. Doppler ultrasound in screening for preeclampsia does have a role in determining the likelihood of developing a complication and possible outcome. Based on the above study, abnormal Doppler can be considered as a reliable predictor for preeclampsia. It is a simple, inexpensive procedure and can be integrated into ultrasound study at the time of anomaly scan to identify high risk pregnancies and provide them with better antenatal care.

**ACKNOWLEDGEMENT**

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REFERENCES


