

UTERINE ARTERY DOPPLER SONOGRAPHY IN SECOND AND THIRD TRIMESTER OF IUGR PREGNANCIES

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Abstracts: Background and objectives: The present study was undertaken to evaluate the role of uterine artery blood velocity waveforms, Systolic/Diastolic ratio (S/D), Pulsatility Index (PI), Resistance Index (RI) as predictor of perinatal outcome in intrauterine growth restriction (IUGR) pregnancies in II and III trimester. **Methods:** In the study group, 50 cases of IUGR were studied in II and III trimester. They were first subjected to ultrasonography biometry and then Uterine artery Doppler sonography. **Results:** In the uterine artery in both the control and study group all the values of S/D ratio, PI and RI decline from II to III trimester but the decline was less and the values were high in the study group as compared to the control group. Thus the present study predicts that, (a) S/D ratio greater than 2.6 and RI greater than 0.58 was found to be abnormal. b) Disappearance of diastolic notch in III trimester is normal where as persistence of notch is abnormal. **Interpretation and conclusion:** Doppler can be considered as one of the important non invasive technique to assess the fetomaternal and uteroplacental circulations. The uterine artery indices were valuable for predicting the outcome of IUGR pregnancies.

Keywords: perinatal outcome, intra uterine growth restriction (IUGR), uterine artery Doppler sonography.

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Introduction:

Colour Doppler sonography or velocimetry is a combination of Doppler ultrasound and gray scale ultrasound to provide simultaneous real time visualization of soft tissues structures and blood flow over the entire scan field.¹

The first Doppler Ultrasound Study of the fetus was done by D.E. Fitzgerald and J.E. Drumm in 1977 specifically on the umbilical artery. He demonstrated that both the uteroplacental and fetoplacental circulations are usually low resistance system.²

Material and Methods:

The present study is undertaken in the 50 normal pregnant women (control group) and 50 high risk pregnant women (study group). The study was done by using a "Colour Doppler Velocimetry" at Marvel Diagnostic Centre, Kolhapur. Approval for this work was obtained from the ethical committee of GMC Miraj & from the Diagnostic Centre. Informed consent was taken from each woman included in the control and study group.

The study was done in the age group between 20 - 35 years from gravida 1 to gravida 5 in both control and study group. The women in control and study group were examined in Second trimester (20 - 24 wks) and Third trimester (26 - 36 wks) of pregnancy. A complete systemic examination of all the pregnant women was done. Pregnant women who did not have any high risk factor like IUGR, pregnancy induced hypertension (PIH), Polyhydramnios, Gestational Diabetes, Pregnancy with Heart Disease, severe anemia of pregnancy etc. were included in the control group. In the study group only those pregnant women having IUGR as detected by ultrasonography biometrical findings were included. The pregnant women in both the groups (control & study) were subjected to Ultrasonography. In both control and study groups the fetal growth was assessed with the biometrical findings on ultrasonography & then they were subjected to Doppler studies.

High risk pregnancy ³Pregnancy is defined as high risk when there is a likelihood of an adverse outcome to the mother and or her baby that is greater than the incidence of that outcome in the

general population. **IUGR** Intrauterine growth retardation is said to be present in those babies whose birth weight is below the tenth percentile of the average for the gestational age.⁴

Doppler Study :

After USG detail Doppler Study was done with Colour Doppler Velocimetry. SA 9900 3D Colour Doppler Machine with 2 – 5 MHZ transducer was used. It is a high resolution colour Ultrasonography Scanner with a remarkably high resolution and deeper penetration which provides a variety of measuring functions. All the evaluation of pictures is computer based and these pictures can be created in any plane on the computer.

Doppler Principle⁵ .The Doppler effects was described by Austrian Physician Johann Christian Doppler in 1842 to explain the appearance of heavenly bodies. The Doppler principle states that when a Ultrasound beam is passed through vessel then there is a back scattering from the moving blood cells and there are returning echoes of different frequencies. This change in frequency is known as the Doppler Frequency shift. Clinically this principle is used to determine the velocity of blood flow in vessels. The difference between the transmitted and reflected frequency is very small and is in the audible range. The outputs are as

Audio Signals

- A. Spectral Wave Forms.
- B. Colour Information
- C. Zero Crossing Recorder

The Control Group: - In II Trimester : The pregnant women assumed a supine position. A coupling jelly was placed on the abdomen and the Doppler probe was placed over the fetus. The Uterine Artery was identified from the Uteroplacental bed and the blood flow through it was recorded .In this way the flow velocity waveforms were examined visually. The same procedure was repeated in III trimester.

The study group: The same procedure was repeated in II and III trimester of pregnancy in the study group. The following values were recorded during the examination of uterine arteries.

1. Peak Systolic Velocity (PSV) or Maximum Systolic Velocity cm/s

2. End Diastolic Velocity (EDV) or Minimum Diastolic Velocity cm/s

From the above values (PSV and EDV) the following parameters were calculated .

- 1 Systolic / Diastolic Ratio (S/D Ratio)
- 2 Pulsatility Index(PI)
- 3 Resistance Index(RI)

With the following formula the wave forms were analysed – ^{5,6}

1. Systolic / Diastolic Ratio (S/D) =

$$\frac{\text{Peak systolic velocity}}{\text{End diastolic velocity}}$$

2. Pulsatility Index (PI) =

$$\frac{\text{Peak systolic velocity} - \text{End diastolic velocity}}{\text{Mean velocity}}$$

3. Resistance Index (RI) =

$$\frac{\text{Peak systolic velocity} - \text{End diastolic velocity}}{\text{Systolic velocity}}$$

All the values of S/D ratio, PI, RI in the control and study groups were arranged in tabular form and were statistically analysed by 'unpaired' and 'paired' t tests.

Result: FIGURE NO. 1 showing parity distribution

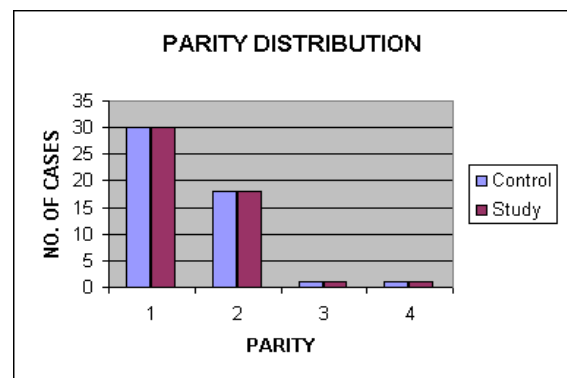


Table:1 Comparison Of Average Values Of S/D,PI And RI Between Control And Study Group Of Pregnant Women In II And III Trimester In Right Uterine Artery.

TRIMESTER II	S/D		DIFF IN MEANS	PI		DIFF IN MEANS	RI		DIFF IN MEANS
	Control	Study		Control	Study		Control	Study	
MEAN	2.7	2.71	0.01	1.06	1.07	0.01	0.57	0.59	0.02
SD	±1.83	±1.06		±0.72	±0.49		±0.15	±0.13	
TRIMESTER III									
MEAN	1.93	2.62	0.69*	0.7	1.02	0.32*	0.46	0.58	0.12*
SD	±0.45	±1.2		±0.25	±0.44		±0.17	±0.11	
DIFF IN MEANS	0.77*	0.09		0.36*	0.05		0.11*	0.01*	

*P< 0.05 significant P > 0.05 insignificant

II Trimester :In the Right Uterine Artery in II trimester (Table no 1)the average S/D ratio values in the control group and in the study group is statistically insignificant (P > 0.05). In the control group the average S/D values decline from II to III trimester and is statistically significant (P < 0.05). In the study group the average S/D values decline from II to III trimesterand is statistically insignificant (P > 0.05).

The average PI values in the control and in the study group is statistically insignificant (P> 0.05). In the control group the average PI values decline from II to III trimester and is statistically significant (P< 0.05). In the study group the average PI values decline fromII to III trimester and is statistically insignificant (P> 0.05).

The average RI values in the control group and in the study group is statistically insignificant ($P > 0.05$). In both control and study group the average RI values decline from II to III trimester and is statistically significant ($P < 0.05$).

III Trimester In III trimester the average S/D ratio, PI and RI values in the control and study group is statistically significant ($P < 0.05$) (Table No-1)

Table:2 : Comparison Of Average Values Of S/D,PI And RI Between Control And Study Group Of Pregnant Women In II And III Trimester In Left Uterine Artery.

TRIMESTER II	S/D		DIFF IN	PI		DIFF IN	RI		DIFF IN
	Control	Study	MEANS	Control	Study	MEANS	Control	Study	MEANS
MEAN	2.63	2.65	0.02	1.03	1.05	0.02	0.56	0.57	0.01
SD	±1.36	±1.31		±0.57	±0.48		±0.12	±0.12	
TRIMESTER III									
MEAN	2.02	2.33	0.31*	0.72	0.91	0.19*	0.49	0.54	0.05*
SD	±0.44	±0.67		±0.93	±0.34		±0.08	±0.1	
DIFF IN MEANS	0.61*	0.32		0.31*	0.14*		0.07*	0.03	

* $P < 0.05$ significant $P > 0.05$ insignificant

II Trimester In the Left Uterine Artery in the II trimester average S/D ratio values in the control and in the study group is statistically

insignificant ($P > 0.05$). In the control group the average S/D values decline from II to III trimester and is statistically significant ($P <$

0.05). In the study group the average S/D values decline from IInd to IIIrd trimester and is statistically insignificant ($P > 0.05$). The average PI values in the control and in the study group is statistically insignificant ($P > 0.05$). In the control and in the study group the average PI values decline from II to III trimester and is statistically significant ($P < 0.05$).

The average RI values in the control and in the study group is statistically insignificant ($P > 0.05$). In the control group the average RI values decline from II to III trimester and is statistically significant ($P < 0.05$). In the study group the average RI values decline from II to III trimester and is insignificant ($P > 0.05$).

III Trimester.

In III trimester the average S/D ratio, PI and RI values in the control and in study group is statistically significant ($P < 0.05$) (Table No-2).

Discussion: Uterine Circulation: - Normally a high resistance pattern with poor diastolic flow is described in the first trimester. The diastolic flow in the uterine artery increases with gestation changing into a low resistance flow pattern.

A notching pattern is noted in the early phase of diastole up to 24 weeks, which denotes the resistance offered by the vessel before the completion of the trophoblastic invasion. This notch disappears by the end of 24 weeks and persistence of notch into the third trimester is considered as impending eclampsia in the mother.⁷

PATHOPHYSIOLOGY OF IUGR

Hypertensive disorders during pregnancy are the most common medical complications encountered. They affect approximately 70 % of primigravida. They are also the most common cause of fetal growth retardation.

In normal human pregnancy the spiral arteries in the placental bed progressively lose their musculoelastic coat or tissue by the migration of the trophoblastic cells into their wall. These trophoblast induced changes involve the whole length of the spiral artery from the intervillous space to its origin in the inner one third of the myometrium. This process widens the spiral arteries and creates a low resistance, low pressure,

statistically insignificant ($P > 0.05$).

high flow system that allows the increased blood supply to the pregnant uterus.

The first stage of these changes involves the decidual part of the spiral arteries and occurs in the first trimester (6 to 12 weeks) . The second stage of these changes involves myometrial part of spiral arteries and occurs in IInd trimester (16 to 25 weeks) of gestation.³

The haemodynamic changes occurring on the maternal side of placenta is reflected in uterine artery by 20 wks. The trophoblastic cells penetrate the maternal spiral arteries in inner 1/3rd disintegrating the inner elastic lamina of spiral arteries by 25 weeks. This results in maximum dilatation and minimum vascular resistance in the vessels.^{8,9,10}

In IUGR the trophoblast induced changes are restricted to the decidual segments of spiral arteries. The myometrial segment of spiral arteries are left intact with their musculoelastic architecture which make them sensitive to vasoconstrictors. This process may account for 2-3 fold decrease in the uteroplacental perfusion^{9,10,11,12}.

The vasospasm is likely to result in endothelial injury. The uteroplacental bed is not spared of the vasoconstrictor effects . Therefore the decrease in uteroplacental perfusion can result in fetal growth retardation and reduction in the amniotic fluid volume.^{3,10,11,12}

Normal placentation is associated with a prostaglandin balance in favour of PGI₂. In IUGR a deficiency of prostacyclin occurs there by affecting trophoblastic invasion of spiral arteries and impairing blood into the intervillous space.

In ascending order increased (Notch pattern in artery) resistance would be diagnostic not only of severe IUGR but impending fetal jeopardy.

The values of S/D ratio, PI and RI in control group and study group in II and III trimester in right and left uterine arteries were more or less equal and difference is not statistically significant and there were no separate references so the discussion of both arteries is taken together.

The haemodynamic changes occurring on the maternal side of the placenta is reflected in the Uterine Artery by 20 weeks of gestation.^{8,10}

In the present study the patients were examined from 20 weeks onwards. All the values decline gradually with increasing gestational age in both control and study group (Table No. 1) All the values were higher in the study group as compared with the control group.

S/D Ratio

In the present study, the mean values of S/D ratio of the control group declined as the gestational age progressed from II to III trimester.

The decrease in the S/D ratio reflects the adequacy of uteroplacental circulation and hence fetoplacental circulation (Fig 2 and 3). Decreasing S/D ratio in uterine artery suggests abundant diastolic flow.¹³

The high end diastolic blood flow velocity and low S/D ratios during later half of pregnancy reflects the low peripheral vascular resistance of the placenta.¹⁴

Similar findings were shown by Fleischer et al in which there was a normal pregnancy outcome when the uterine artery S/D ratio was less than 2.6 in the III trimester.¹⁵

The observations in the present study correlates with C. J. Bhatt et al, Trudinger et al and Fleischer et al.^{8,14,15} But the findings did not correlate with Yang C.S. who says that in the normal pregnancy the uterine artery S/D ratio remained constant between 1.8 to 1.9 from 20th to 40th week.¹⁶

In the study group the S/D ratio decline from II to III trimester (Table No 1). The difference in means was statistically insignificant ($P > 0.05$). (Table No - 1). The decrease S/D ratio in III trimester is probably due to the trophoblastic cells invade and destroy the vascular smooth muscle cells of the spiral arteries from the Ist trimester onwards and is completed by 25 weeks. Destruction of muscle coat leads to fall in peripheral vascular resistance and thus decrease S/D ratio in III trimester.^{4, 8,9,10,17}

In the present study the difference of mean values of S/D ratio between control and study group is insignificant ($P > 0.05$) in the II trimester because the process of trophoblastic invasion is still going on in both control and study group. This is the normal physiological process and is completed by 25 weeks. It denotes the resistance offered by the

vessel before the completion of trophoblastic invasion.^{4,9, 8,17}

The S/D ratio of the uterine artery greater than 2.6 after 26 weeks is abnormal.^{4,9, 8,17} According to Yang C.S. et al after 30th weeks the uterine artery S/D ratio greater than 2.6 is abnormal.¹⁶

In the present study the S/D ratio in the III trimester is 2.6 and the difference of mean of S/D ratio between control and study group is statistically significant ($P < 0.05$). The high S/D ratio in IUGR (Study group) is due to prostacyclin deficiency and due to prostacyclin deficiency trophoblastic invasion is restricted to the decidual segment of spiral arteries only. The myometrial segments of the spiral arteries are left intact with their musculoelastic coat architecture. This makes them sensitive to vasopressors leading to Vasoconstriction and increase in peripheral resistance. Increase in peripheral resistance means decrease in uteroplacental circulation which affects fetoplacental circulation and fetal growth.^{4,9,8,17}

Pulsatility index (PI) –

In the control group the mean PI values decline from II to III trimester (Table No. 1). The difference in means was statistically significant ($P < 0.05$). According to Ochi et al, the mean PI values in the control group fall from 0.70 ± 0.15 to 0.65 ± 0.13 from 25 to 36 weeks. The results in the present study do not match with that of Ochi et al.¹⁸

In the study group the mean PI values decline from 1.07 ± 0.49 to 1.02 ± 0.44 from II to III trimester (Table no 1). The difference in mean was statistically insignificant ($P > 0.05$). The difference of mean PI values were statistically insignificant ($P > 0.05$) in II trimester but significant ($P < 0.05$) in III trimester when compared with the control group. (Table No 1)

This is because the development of IUGR is associated with defective trophoblastic invasion and conversion of spiral arteries into low resistance uteroplacental arteries. Thus a high uterine artery, pulsatility index reflects a defective development of placental bed spiral arteries in pregnancies complicated by IUGR. Several other workers had similar findings.^{4,8,19,,20,21,22 ,23,24}

In 1997 Zimmermann P et al founded combination of all parameters (S/D, PI, RI) is superior to single parameter.²⁵

According to Hofstaetter C. et al diastolic notch was more important in predicting abnormal pregnancy outcome as compared to increased PI.²⁶

Resistance Index:- (RI) -

In this study the RI in the control group declined from 0.57 ± 0.15 to 0.46 ± 0.17 from II to III trimester (Table No. 1). The difference in means was statistically significant ($P < 0.05$)

The normal range of RI after 26 weeks is between 0.45 to 0.58.⁶

In the study group the average values of RI ranges from 0.59 ± 0.13 to 0.58 ± 0.11 from II to III trimester (Table No 1) . The difference in means was statistically significant ($P < 0.05$). The difference of average values of RI were statistically insignificant ($P > 0.05$) in II trimester when compared with the control group . It denotes the resistance offered by the vessel before the completion of trophoblastic invasion of spiral arteries that is taking place at 24 weeks.⁷

The mean of both uterine arteries RI (RI $>$ or $=$ 0.66) and the presence of diastolic notch in the placental uterine artery at 22 to 24 weeks have a higher predictive value for subsequent development of IUGR rather than separate evaluation of two arteries.²³

The high resistance in both right and left uterine arteries (RI > 0.55) (and Bilateral Notches) (Fig 4 and 5) at 20 weeks is associated with increased risk of subsequent development of complication.^{23,27,28}

At 22-24 weeks RI > 0.58 was abnormal and RI $>$ or $= 0.7$ was very abnormal.

The mean RI of both uterine arteries at 24 weeks of gestation when greater or equal to 0.58 was abnormal.²⁹

In the present study the findings in II trimester in the study group match with the above workers.^{28,29,30}

The high resistance in the III trimester is due to defective trophoblastic invasion and conversion of arteries into low resistance uteroplacental arteries that is occurring due to prostacyclin deficiency and the RI > 0.58 after 26 weeks is abnormal.^{6,8,23,24}

In the present study unilateral notch was seen in 5 women and bilateral notch in 12 women in II trimester.

The unilateral notch disappeared in 3 pregnant women in III trimester where as in 2 pregnant women it persisted till term. These 2 pregnant

women also showed the bilateral notch in III trimester.

The bilateral notch which was seen in 12 women in II trimester disappear in 9 women while it persisted in 3 women in the III trimester. Seven women who did not showed any notch in II trimester developed a unilateral notch in the III trimester in 4 women and 3 women developed a bilateral notch in the III trimester.

A notching pattern is noted in the early phase of diastole upto 24 weeks, which denotes the resistance offered by the vessels before the completion of trophoblastic invasion. This notch disappears by the end of 24 weeks. Persistence of notch in III rd trimester is considered as impending PIH in the mother.⁷ The presence of the early diastolic notch is normal phenomenon upto 26 weeks of gestation. Presence of notch after 26 weeks is a bad indicator suggesting increased impedance to flow. Also persistence of II trimester notch in III trimester is abnormal.^{8,23,24}

Fay R. A. et al, Liberati M et al and Miyakoshi et al demonstrated appearance of diastolic notch in the uterine artery at 22-24 weeks is suggestive of subsequent development of PIH and IUGR.^{27,31,,32,33,34}

The persistence of II trimester notch in the III trimester is abnormal.^{8,34} Therefore the present study is conducted in both II and III trimester in order to see the changes in III trimester.

Bilateral notches (Fig4 and 5) rather than the unilateral notches were more predictive of poor pregnancy outcome.^{23,24,25,35,36}

Fig 2 color Doppler of Right Uterine Artery shows normal waveform pattern

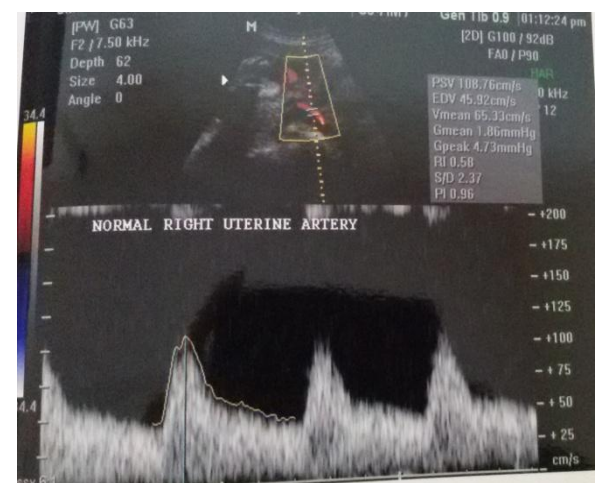


Fig 3 color Doppler of Left Uterine Artery shows normal waveform pattern

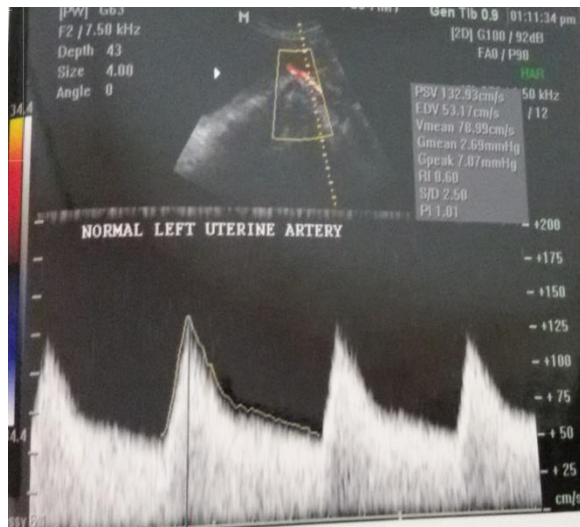


Fig 4 Abnormal Right Uterine Artery waveform pattern showing Diastolic Notch

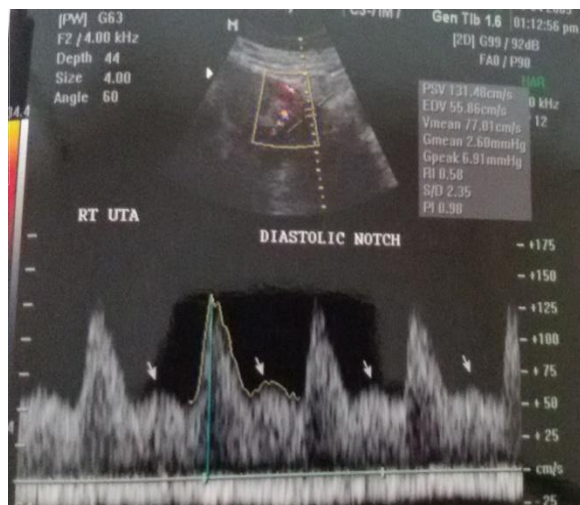


Fig 5 Abnormal Left Uterine Artery waveform pattern showing Diastolic Notch



Conclusion:

The abnormal Uterine Doppler velocimetry is suggestive of maternal pathology. Thus the present study concludes that –In the uterine artery in both the control and study group all the values of S/D ratio, PI and RI decline from II to III trimester but the decline was less and the values were high in the study group as compared to the control group. Thus the present study predicts that -

- S/D ratio greater than 2.6 and RI greater than 0.58 was found to be abnormal.
- Disappearance of diastolic notch in III trimester is normal where as persistence of notch is abnormal.

Thus the Doppler velocimetry is a primary tool for fetomaternal surveillance in hypertensive and IUGR pregnancies because the changes in uterine circulations (S/D ratio > 2.6 and RI > 0.58 after 26 weeks) strongly correlate with pregnancy outcome. The efficiency of colour Doppler velocimetry helps to take timely action, plan the treatment and also counsel the patient in their future pregnancies.

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