UMBILICAL ARTERY DOPPLER INDICES IN IUGR PREGNANCIES

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Abstract: Background and objectives: Doppler velocimetry studies of placental and fetal circulation can provide and important information regarding fetal wellbeing providing an opportunity to improve fetal outcome. The present cross sectional study was undertaken to evaluate the role of umbilical artery blood velocity waveforms, Systolic/Diastolic ratio (S/D), Pulsatility Index (PI), Resistance Index (RI) as predictor of perinatal outcome in intrauterine growth retardation (IUGR) pregnancies in IInd and IIIrd trimester. **Methods:** In the study group, 50 cases of IUGR were studied in IInd and IIIrd trimester. They were first subjected to ultrasonography biometry and then umbilical artery Doppler sonography. **Results:** In both control and study group the values of S/D ratio, PI and RI in umbilical artery decline during IInd to IIIrd trimester. 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 3 and RI greater than 0.7 after 26th weeks of pregnancy was found to be abnormal.

b) Absent End Diastolic Velocity (AEDV) & Reverse End Diastolic Velocity (REDV) were predictive of poor fetal outcome.

Interpretation and conclusion: The umbilical artery indices were valuable for predicting the outcome of IUGR pregnancies.

Key words: Adverse outcomes, fetal growth restriction, umbilical artery Doppler sonography.

Abbreviations: Absent End diastolic velocity (AEDV), Intrauterine Growth Restriction / Retardation (IUGR), Pulsatility Index (PI), Resistance Index (RI), Reverse End Diastolic Velocity (REDV), Systolic/Diastolic Ratio (S/D).

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Introduction

"Nations Health is Nations Wealth". The young ones are said to be the pillars of the nation's future. It is therefore very important to concentrate on the healthy birth and healthy growing of the fetus.

As the pregnancy advances the growth of the fetus also increases in proportion of the age of gestation. The growth of the fetus depends upon the nutrition supplied by placenta. So adequate functioning of placenta is essential for the appropriate growth of the fetus.

The high risk pregnancy has a multifactorial etiology. Its incidence is high in developing countries as compared to the developed countries.

The high risk pregnancy continues to represent a significant and growing problem in perinatal morbidity and mortality. Since there does not seem to be any practical way to present these problems, the only realistic approach seem to be early diagnosis.

The development of ultrasound and its application to the obstetrics was a revolutionary event in the history of perinatology. One of the main goals of the prenatal testing is to identify the fetuses at increased risk for prenatal morbidity and mortality.

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[1].

The Doppler Ultrasound has provided a safe noninvasive and rapid method of assessing the physiology and pathophysiology of fetal and maternal uterine circulation[2].

So it has motivated to undertake the present study to evaluate the fetal growth with Color Doppler Velocimetry in normal and high risk pregnancies. In the present study the commonest high risk pregnancy like Intrauterine Growth Retardation (IUGR) is being studied.

Aim:-

To evaluate the Color Doppler Velocimetry of the umbilical artery in the control and study group to determine its predictive value on fetal outcome.

Objectives:-

1. To assess the fetal growth by ultrasonography.
2. To assess the fetal growth by measuring S/D ratio, PI and RI in the umbilical artery in the control group by Color Doppler Velocimetry.
3. To assess the fetal growth by measuring S/D ratio, PI and RI in the umbilical artery in the study group by Color Doppler Velocimetry.
4. To compare the fetal growth between study and control group.

Material and methods:-

The present study is undertaken in the 50 normal pregnant women (control group) and 50 high risk pregnant women i.e. IUGR pregnancies (study group). The study was undertaken by using a "Color 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 weeks) and third trimester (26 - 36 weeks) of pregnancy.

A complete systemic examination of all the pregnant women was done. Pregnant women who did not have any high risk factors like PIH, polyhydramnios, gestational diabetes, pregnancy with heart disease, severe anemia of pregnancy were included in the control group.

In the study group only those pregnant women having IUGR as detected by ultrasonography biometrical findings were included.

High Risk Pregnancy: -

It 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 the outcome in the general population[3]. High risk pregnancies like IUGR are included in the present study.

The pregnant women in both the groups (control and study) were subjected to ultrasonography. It includes study of placenta, liquor and biometry.

In both control and study groups the fetal growth was assessed with biometrical findings on ultrasonography and then they were subjected to Doppler studies.

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 Color Doppler Velocimetry. SA 9900 3D color Doppler machine made in Korea with 2 – 5 MHz transducer was used.

With Doppler ultrasonography the circulatory system was studied and the color flow imaging points specifically at the vascular system.

Color 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 [5].

Doppler Principle [5, 6]

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 an 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

A. Audio signals

B.   Spectral wave forms.

C.   Color information

D.   Zero crossing recorders

The Control Group: - In IInd Trimester

The pregnant women were given a supine position. A coupling jelly was placed on the abdomen and the Doppler probe was placed over the abdomen.

The umbilical artery in the umbilical cord was identified by the typical audio signals heard when the blood flows through it. The blood flow through it was recorded in the form of characteristic shape of the flow velocity waveforms on the oscilloscope.

The color flow highlights the umbilical cord and vessels. The Doppler waveforms within the umbilical artery change with the gestational age[7].

The same procedure was repeated in the control group in IIIrd trimester.

The study group: -

The same procedure was repeated in IInd and IIIrd trimester of pregnancy in the study group.

The following values were recorded during the examination of the umbilical arteries.

1. Peak systolic velocity (PSV) or Maximum systolic velocity in cm/s

2. End diastolic velocity (EDV) or Minimum diastolic velocity in 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 analyzed –

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 analyzed by 'unpaired t test' and 'paired ' test'.

Observations and Results

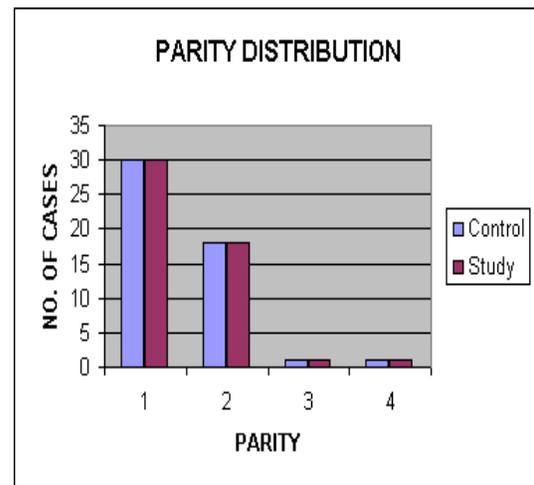**Figure No. 1 showing parity distribution**

PARITY DISTRIBUTION

TABLE NO. 1 showing umbilical artery S/D ratio, PI and RI values in IInd and IIIrd trimester

Trimester	S/D ratio		PI		RI	
	Control	Study	Control	Study	Control	Study
IInd trimester	1.7-5.37	1.77-8.99	0.72-1.49	0.7-1.87	0.44-0.81	0.44-0.89
IIIrd trimester	1.8-4.08	0-14.3	0-1.35	0.7-2.19	0.45-0.75	0.33

Table No.1 shows in the umbilical artery in IInd trimester; the individual values of S/D ratio in the control group ranges from 1.7 to 5.37 and in the study group ranges from 1.77 to 8.99.The individual PI values in the control group ranges from 0.72 to 1.49 and in the study group ranges from 0.7 to 1.87. The individual RI values in the control group ranges from 0.44 to 0.81 and in the study group ranges from 0.44 to 0.89. In the IIIrd trimester, this table shows the individual values of S/D ratio in the control ranges from 1.8 to 4.08 and in the study group ranges from 0 to 14.3.

The individual PI values in the control group ranges from 0 to 1.35 and in the study group ranges from 0.7 to 2.19.

The individual RI values in the control group ranges from 0.45 to 0.75 and in the study group ranges from 0.33 to 1.

Table No. 2 Shows in the umbilical artery in IInd trimester, the average S/D ratio values in the control group is 3.35 ± 0.79 and in study group is 3.38 ± 0.86. The difference in means is 0.03 and is statistically insignificant (P > 0.05). In the control group the average S/D values decline from 3.35 ± 0.79 to 2.54 ± 0.55 during IInd to IIIrd trimester. The difference in means is 0.81 and is statistically significant (P < 0.05). In the study group the average S/D values decline from 3.38 ± 0.86 to 3.29 ± 2.43 during IInd to IIIrd trimester. The difference in means is 0.09 and is statistically insignificant (P > 0.05).

The average PI values in the control group 1.35 ± 1.63 and in the study group is 1.36 ± 0.24. The difference in means is 0.01 and is statistically insignificant (P > 0.05). In the control group the average PI values decline from 1.35 ± 1.63 to 0.91 ± 0.21 during IInd to IIIrd trimester. The difference in means is 0.44 and is statistically significant (P < 0.05). In the study group the average PI values decline from 1.36 ± 0.24 to 1.25 ± 0.44 during IInd to IIIrd trimester. The difference in means is 0.11 and is statistically insignificant (P > 0.05).

The average RI value in the control group is 0.68 ± 0.91 and in the study group is 0.72 ± 0.08. The difference in means is 0.04 and is statistically significant (P < 0.05). In the control group the average RI values decline from 0.68 ± 0.91 to 0.59 ± 0.08 during IInd to IIIrd trimester. The difference in means is 0.09 and is statistically significant (P < 0.05). In the study group the average RI values decline from 0.72 ± 0.08 to 0.71 ± 0.15 during IInd to IIIrd trimester. The

Table No.2 showing comparison of average values of S/D, PI and RI between control and study group of pregnant women in II and III trimester in umbilical artery

TRIMESTER II	S/D		DIFF IN MEANS	PI		DIFF IN MEANS	RI		DIFF IN MEANS
	Control	Study		Control	Study		Control	Study	
MEAN SD	3.35 ±0.79	3.38 ±0.86	0.03	1.35 ±1.63	1.36 ±0.24	0.01	0.68 ±0.91	0.72 ±0.08	0.04*
TRIMESTER III MEAN SD	2.54 ±0.55	3.29 ±2.43	0.75	0.91 ±0.21	1.25 ±0.44	0.34*	0.59 ±0.08	0.71 ±0.15	0.12*
DIFF IN MEANS	0.81*	0.09		0.44*	0.11		0.09*	0.01	

Difference in means is 0.01 and is statistically insignificant (P > 0.05).

IIIrd Trimester

In IIIrd trimester the average S/D ratio values in the control group is 2.54 ± 0.55 and in the study group is 3.29 ± 2.43.

The difference in means is 0.75 and is statistically insignificant (P > 0.05).

The average PI value in the control group is 0.91 ± 0.21 and in the study group is 1.25 ± 0.44. The difference in means is 0.34 and is statistically significant (P < 0.05).

The average RI value in the control group is 0.59 ± 0.08 and in the study group is 0.71 ± 0.15. The difference in means is 0.12 and is statistically significant (P < 0.05).

Discussion:-

The purpose of the present work was to study the Doppler Velocimetry of umbilical artery in the defined high risk group to determine its predictive value on the fetal outcome. In 1995 Usha Krishna found umbilical and arcuate vessel Doppler blood flow velocimetry is a most useful tool in confirming IUGR[8]. A total of 100 cases, 50 cases from normal pregnant women i.e. (control group) and 50 cases from the high risk group i.e. (study group) were studied in IInd and IIIrd trimesters of pregnancy.

Umbilical Artery:-

Umbilical artery velocimetry correlates with hemodynamic changes in the feto placental circulation. With the increase in number of

tertiary stem villi and arterial channels fetoplacental compartment develops and the impedance in the umbilical artery decreases. From 15th weeks of gestation umbilical artery resistance declines and the diastolic component appears in the waveform during the early second trimester[9]. There were differences between waveforms recorded from normal and complicated pregnancies[10, 11]. There is relationship between the elevated umbilical S/D ratio and vascular lesions of the placenta.   The vascular lesions are characterized by reduced number of small muscular arteries in the tertiary stem villi[12, 13].

In the present study all the values declined gradually with increasing gestational age in both control and study group (Table No.2). All the values were higher in the study group as compared with the control group.

S/D Ratio:-
Normally the umbilical artery S/D ratio declined from 3.9 to 2.1 from 20th to 38th weeks[14]. The S/D ratio less than or equal to 3 is considered normal[9].

In the control group the average values of S/D ratio decline from 3.35 ± 0.79 to 2.54 ± 0.55 during IInd to IIIrd trimester. The difference in means was statistically significant (P < 0.05) (Table No.2).

This gradual decline with advancing gestational age is due to decrease in the umbilical artery resistance. The development of small arteries and arterioles of tertiary villi are responsible for major drop in arterial resistance across the placental vascular bed. This is important to maintain an adequate fetoplacental circulation to fulfill the demands of the growing fetus[9, 14, 15].

In the study group the average values of S/D ratio decline from 3.38 ± 0.86 to 3.29 ± 2.43 during IInd to IIIrd trimester. The difference in means was statistically insignificant (P > 0.05) (Table No. 2).

The difference in means of S/D ratio was statistically insignificant (P > 0.05) in IInd trimester but significant in IIIrd trimester when compared with the control group (Table No .2). The high values in the study group represent the pathological angiogenesis resulting in increased resistance[15].

After 30th weeks the umbilical artery S/D ratio greater than or equal to 3 is abnormal[14]. But according to C.J.Bhatt et al, S/D ratio greater than or equal to 3 is abnormal between 28 – 36 weeks[9]. Abnormal umbilical artery S/D ratio alone or with abnormal uterine artery S/D ratio was associated with poor pregnancy outcome as judged by incidence of IUGR, caesarean section rate, low birth weight, perinatal morbidity and mortality and prematurity[16, 17, 18, 19].

In the present study 50 women had IUGR. Out of 50 IUGR patients, 22 patients showed low end diastolic flow in IInd trimester. Out of the 22, 8 pregnant women continued to show low end diastolic flow in IIIrd trimester, 4 showed AEDV and 1 showed REDV in the IIIrd trimester.   11 women directly showed the low end diastolic velocimetry in IIIrd trimester. Total of 33 out of 50 IUGR patients showed abnormal flow velocity waveforms.

A decrease in number of villi in the placenta gives rise to abnormal waveforms of the umbilical artery. AEDV or REDV indicates extremely increased placental resistance[6, 17, 18, 19].

The patients with AEDV in umbilical artery should undergo intensive surveillance and EDV represents pre-terminal fetal state and showed gravest outcome[9,17,18,19].

Pulsatility Index (PI):-
 In the present study average PI values in the control group decline from 1.35 ± 1.63 to 0.91 ±0.21 from ii to III trimester (Table No 2) . The difference in means was statistically significant (P < 0.05). The PI values of the study group decline from 1.36 ± 0.24 to 1.25 ± 0.44 (Table No. 2) from II to
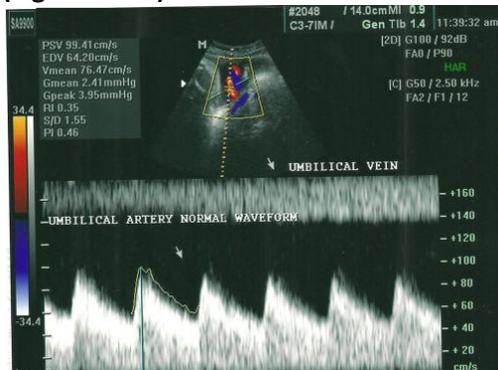
III trimester. The difference in means was statistically insignificant (P > 0.05). The difference in means was statistically insignificant (P > 0.05) in II and significant (P < 0.05) in III trimester when compared with the control group. (Table No 2).

Probably the high PI values in study group is due to reduced tertiary villi formation leading to increased resistance, reduction in the end diastolic flow velocities and reversal of end diastolic flow velocity; there by indicating placental dysfunction , IUGR and fetal distress[7, 17,18,19,20, 21].

Resistance Index (RI):-

In the present study, the RI values in the control group decline from 0.68 ± 0.91 to 0.59 ± 0.08 during IInd to IIIrd trimester (Table No 2). The difference in means was statistically significant (P < 0.05). The RI in the study group decline from 0.72 +/- 0.08 to 0.71 +/- 0.15 during IInd to IIIrd trimester. The difference in means was statistically insignificant (P > 0.05) (Table No 2). The average RI values were significant (P< 0.05) in both IInd and IIIrd trimester when compared with the control group. The high RI value in the study group is due to pathological angiogenesis and the RI > 0.7 is abnormal[6, 17, 18, 19].

Figure No. 2:-Color Doppler of the umbilical artery shows a normal waveform pattern with low impedance, high diastolic flow and decreased pulsatility index (Figure No. 2)

Abnormal umbilical artery waveform patterns showing markedly reduced diastolic flow and high resistance Figure

No. 3(a), absent diastolic flow Figure No. 3(b)) and reverse diastolic flow Figure No. 3(c)
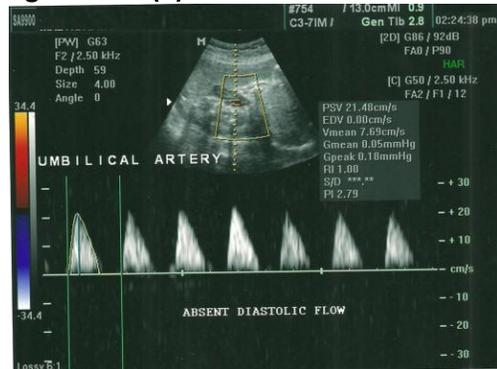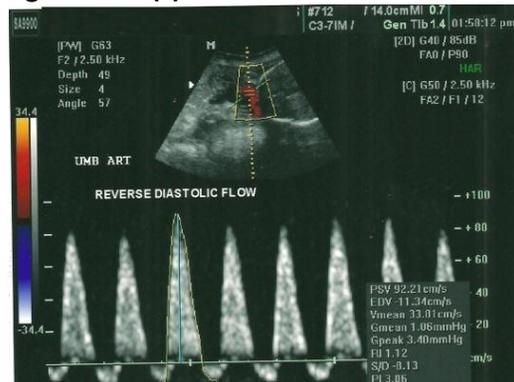
Figure No. 3(a)

Figure No. 3(b)

Figure No. 3(c)

SUMMARY AND CONCLUSION:-

Color Doppler study of various arteries indicating their flow pattern during pregnancy is an important tool for the obstetricians when dealing with complicated pregnancies such as those associated with PIH and IUGR. Abnormal flow indices are seen in these pregnancies.

Also abnormality in blood flow indices directly correlate with the neonatal

outcome in the form of birth weight, APGAR scores and neonatal morbidity. Color Doppler can be used as an important diagnostic aid to detect fetal compromise at an early stage and help in early management of patients before the fetus suffers irreversible damage or dies in utero. Doppler velocimetry can provide important information about the umbilical circulation. The abnormal umbilical circulation is suggestive of fetal pathology (IUGR).

In the umbilical artery in both the control and study group the values of S/D ratio, PI and RI decline during IInd to IIIrd trimester. 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 greater than 3 and RI greater than 0.7 after 26th weeks was found to be abnormal.

b) AEDV & REDV were predictive of poor fetal outcome.

Thus the Doppler velocimetry is a primary tool for fetomaternal surveillance in IUGR pregnancies because the changes in umbilical circulations (S/D ratio > 3 and RI > 0.7 after 26th weeks) strongly correlate with pregnancy outcome. The efficiency of color Doppler velocimetry helps to take timely action, plan the treatment and also counsel the patient in their future pregnancies.

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