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Research Article

Correlation of fetal middle cerebral artery Doppler indices in IUGR pregnancies

Padmaja R. Desai*, Rupesh P. Dahilkar, S. M. Tiwale, Rajey M. Desai and Arati A. Joshi

Department of Physiology, D Y Patil Medical College, Kolhapur, M.S., India, 416006, 4 Director, Radiologist, Marvel Diagnostic Center, Kolhapur, M.S. India

***Correspondence Info:**
Dr. Mrs. Padmaja R. Desai
Associate Professor,
Department of Physiology,
D. Y. Patil Medical College, K. Bawada, Kolhapur, 416006, (M.S.), India.
E-mail: padmajardesai@gmail.com

Abstract

Background and objectives: Doppler velocimetry studies of placental and fetal circulation can provide important information regarding fetal well being providing an opportunity to improve fetal outcome. The present study was undertaken to evaluate the role of fetal middle cerebral 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 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 middle cerebral artery Doppler sonography.

Results: In both control and study group the values of S/D ratio, PI and RI in middle cerebral artery decline during IInd to IIIrd trimester. The values were lower in the study group as compared to the control group. Thus the present study predicts that;

a) Lower PI values were suggestive of fetal hypoxia. b) The lower values are due to vasodilatation due to hypoxia in order to supply more blood to the brain to protect it from the damaging effects of hypoxia. Thus the brain is spared from damage.

Interpretation and conclusion: Doppler can be considered as one of the important non invasive technique to assess the fetomaternal and uteroplacental circulations. The middle cerebral artery indices were valuable for predicting the outcome of IUGR pregnancies.

Keywords: perinatal outcome, fetal growth restriction, middle cerebral artery Doppler sonography.

1. Introduction

Intrauterine growth restriction (IUGR) defined by body mass and weight loss less than 10th percentile is regarded as dangerous pregnancies due to complications resulted from delivery interventions in mother and later neonatal complications[1, 2].

A quick, easy and accurate method of estimation of fetal growth in utero would be of obvious benefit to the clinician practicing the modern obstetrics. The time honored ritual of palpating the uterine fundus is notoriously inaccurate, especially at the lower and upper extremities of the expected size for dates. The sonographic methods have an advantage of being more accurate, simple and noninvasive.

Now the clinical application of Doppler principle to ultrasound and its employment in the investigation of blood flow velocities has revolutionized the study of human fetal circulation dynamics[3,4,5,6,7,8].

Although the Doppler ultrasound techniques has been investigated for many years, it wasn't until the development of duplex Doppler in the late 1970's and early 1980's that the technique started to become an increasingly important component of ultrasound examinations generally. Color Doppler and, more recently power Doppler ,second harmonics and echo enhancing agents have arrived and further expanded the value of Doppler technique in relation to both ultrasound examinations in general and vascular assessment in particular[9].

The Doppler effect was described by Austrian Physicist Johann Christian Doppler in 1842[10].

In 1977, the first Doppler ultrasound study of fetus was done by Fitzgerald and Drumm. He studied vessels on both the sides of the placenta, umbilical artery and umbilical vein. He studied that both the uteroplacental and fetoplacental circulations are usually low resistance systems[11].

Several workers have measured the Peak Systolic / End Diastolic ratio (S/D), Pulsatility Index (PI) and Resistance Index (RI) in the uterine artery only. Some have measured the S/D, PI and RI in the umbilical artery and fetal middle cerebral artery[5,6,7,8, 9,10,11].

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 Restriction (IUGR) is studied.

1.1 Aim

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

1.2 Objectives

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

2. Material and Method

The present study is undertaken in the 50 normal pregnant women (control group) and 50 high risk pregnant women (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.

1. The study was done in the age group between 20 - 35 years from gravida 1 to gravida 5 in both control and study group.
2. The women in control and study group were examined in Second trimester (20 - 24 weeks) and Third trimester (26 - 36 weeks) of pregnancy.
3. A complete systemic examination of all the pregnant women was done. Pregnant women who did not have any high risk factor were included in the control group.
4. In the study group only those pregnant women having IUGR as detected by ultrasonography biometrical findings were included.

Pregnant women having other high risk factors like pregnancy induced hypertension (PIH), Polyhydramnios, Gestational Diabetes, Pregnancy with Heart Disease, Severe anemia of pregnancy etc. were excluded.

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 the above mentioned biometrical findings on ultrasonography and then they were subjected to Doppler studies.

2.1 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.

It is a high resolution color Ultrasonography Scanner with a remarkably high resolution and deeper penetration which provides a variety of measuring functions. The additions of three dimensional with TV probes have now added a new dimension. It is now possible to study in great details and with more accuracy. All the evaluation of pictures is computer based and these pictures can be created in any plane on the computer.

2.2 Doppler Principle [10, 12]

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 assumed a supine position. A coupling jelly was placed on the abdomen and the Doppler probe was placed over the fetus. The middle cerebral artery indicates intracerebral flow through the internal carotid artery. It can be studied at the base of the brain running through the lateral sulcus over the anterior perforator substance. Color Doppler sonography permits easy visualization of the circle of Willis to identify the MCA [13].

The blood flow through it was also recorded. In this way the flow velocity waveforms were examined visually.

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 middle cerebral artery.

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 analyzed – [9, 14]

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

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

2. Pulsatility Index (PI) =

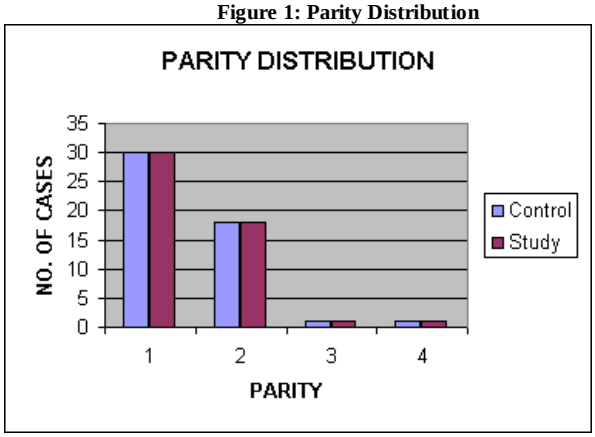
$$\text{-} \quad \frac{\text{Peak systolic velocity} - \text{End diastolic velocity}}{\text{Mean velocity}}$$

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' and 'paired' t tests.

Figure 1: Parity Distribution



According to Fig. No.1, in the control and study group 30 cases were having parity 1; 18 cases were having parity 2; 1 case of parity 3 and 1 case of parity 4.

Table No 1- shows in the Fetal Middle Cerebral Artery in IInd trimester the individual values of S/D ratio in the control group ranges from 0 to 64.3 and in the study group ranges from 0 to 64.3

The individual PI values in the control group ranges from 0.7 to 2.56 and in the study group ranges from 0.01 to 3.01.

The individual RI values in the control group ranges from 0.38 to 1 and in the study group ranges from 0.38 to 1.

In the IIIrd trimester this table shows the individuals values of S/D ratio in the control group ranges from 1.57 to 78.3 and in the study group ranges from 1.88 to 77.54.

The individuals PI values in the control group ranges from 0 to 2.67 and in the study group ranges from 0.78 to 2.97.

The individuals RI values in the control group ranges from 0.19 to 0.99 and in the study group ranges from 0.47 to 0.99.

Table No. 1 showing middle cerebral artery S/ D ratio, PI and RI values in IInd and III rd trimester

Trimester	S/D ratio		PI		RI	
IInd trimester	Control	Study	Control	Study	Control	Study
	0 - 64.3	0 - 64.3	0.7 - 2.56	0.01 - 3.01	0.38 - 1	0.38 - 1
IIIrd trimester	1.57 – 78.3	1.88 – 77.54	0 -2.67	0.78 – 2.97	0.19 – 0. 99	0. 47 – 0.999

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 Fetal Middle Cerebral Artery

TRIMESTER II	S/D		DIFF IN MEANS	PI		DIFF IN MEANS	RI		DIFF IN MEANS
	Control	Study		Control	Study		Control	Study	
MEAN	9.86	9.7	0.16	1.74	1.56	0.18	0.82	0.8	0.02
SD	±15.38	±12.03		±0.54	±0.56		±0.12	±0.13	
TRIMESTER III									
MEAN	7.41	7	0.41	1.69	1.52	0.17*	0.8	0.73	0.07*
SD	±10.98	±8.76		±0.46	±0.57		±0.2	±0.15	
DIFF IN MEANS	2.45	2.7		0.05	0.04		0.02	0.07*	

*P< 0.05 significant, P > 0.05 insignificant

Table. 2 shows in the Fetal Middle Cerebral Artery in II Trimester the average S/D ratio values in the control group is 9.86 ± 15.38 and in the study group is 9.7 ± 12.03. The difference in means is 0.16 and is statistically insignificant (P > 0.05). In the control group the average S/D values decline from 9.86 ± 15.38 to 7.41 ± 10.98 from II to III trimester. The difference in means is 2.45 and is statistically insignificant (P > 0.05). In the study group the average S/D values decline from 9.7 ± 12.03 to 7 ± 8.76 from II to III trimester. The difference in means is 2.7 and is statistically insignificant (P > 0.05).

The average PI value in the control group is 1.74 ± 0.54 and in the study group is 1.56 ± 0.56. The difference in means is 0.18 and is statistically insignificant (P > 0.05). In the control group the average PI values decline from 1.74 ± 0.54 to 1.69 ± 0.46 from II to III trimester. The difference in means is 0.05 and is statistically insignificant (P > 0.05). In the study group the average PI values decline from 1.56 ± 0.56 to 1.52± 0.57 from II to III trimester. The difference in means is 0.04 and is statistically insignificant (P > 0.05).

The average RI values in the control group is 0.82 ± 0.12 and in the study group is 0.8 ± 0.13. The difference in means is 0.02 and is statistically insignificant (P > 0.05). In the control group the average RI values decline from 0.82 ± 0.12 to 0.8 ±- 0.2 from II to III trimester. The difference in means is 0.02 and is statistically insignificant (P > 0.05). In the study group the average RI values decline from 0.8 ± 0.13 to 0.73 ± 0.15 from II to III trimester. The difference in means is 0.07 and is statistically significant (P < 0.05).

IIIrd Trimester

In III Trimester the average S/D ratio values in the control group is 7.41 ± 10.98 and in the study group is 7 ± 8.76. The difference in means is 0.41 and is statistically insignificant (P > 0.05)

The average PI values in the control group are 1.69 ± 0.46 and in study group is 1.52 ±0.57. The difference in means is 0.17 and is statistically significant (P < 0.05)

The average RI values in the control group are 0.8 ± 0.20 and in the study group is 0.73 ± 0.15. The difference in means is 0.07 and is statistically significant (P < 0.05)

3. Discussion

The purpose of the present work was to study the Doppler Velocimetry of middle cerebral artery in the defined high risk group to determine its predictive value on the fetal outcome. Fetal Middle cerebral artery is a better indicator of fetal compromise. Several published studies have confirmed the importance of assessment of the cerebral circulation as an indicator of fetal hypoxia [11, 15, 16, 17, 18].

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.

Fetal Middle Cerebral Artery –

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

3.1 S/D Ratio

In the present study in the control group the mean values of S/D ratio decline gradually from 9.86 ± 15.38 to 7.41 ± 10.98 from II to III trimester (Table No. 2). The difference in means was statistically insignificant (P > 0.05).

Probably the decline in the values with the increase in the gestational age is due to decrease in vascular resistance in the fetal middle cerebral artery so as to meet the oxygen demands of the growing fetus. In the normal pregnancy, the waveform of blood in fetal intracranial artery has high S/D ratio [12, 19].

In the study group the average values of S/D ratio decline from 9.7 ± 12.03 to 7.0 ± 8.76 from II to III trimester (Table No 2). The difference in means was statistically insignificant (P > 0.05).The values were lower in the study group as compared to the control group. The difference in means was statistically insignificant (P > 0.05) in II trimester and in III trimester when compared with the control group.

In normal fetus there is little diastolic flow in the MCA. Probably the lower values in patients of IUGR is due to still further fall in peripheral resistance that is occurring due to vasodilatation due to hypoxia and diastolic flow increases. This is known as "Brain Sparing Effect" [12, 15, 16, 18, 20]. The brain sparing effect denotes the redistribution of available blood from the abdominal and peripheral vessels to the brain which is a vital organ requiring adequate perfusion [11, 13, 16].

3.2 Pulsatility Index (PI)

The PI values in the control group decline from 1.74 ± 0.54 to 1.69 ± 0.46 from II to III trimester. The difference in means was statistically insignificant (P > 0.05) (Table No 2).

PI index is very important in MCA as this is a vessel of high resistance with low end diastolic flow. Decline in the values with the increasing gestational age is due to decrease in vascular resistance so as to meet the oxygen demands of the growing fetus [12, 21].

In the study group the average PI values decline from 1.56 ± 0.56 to 1.52 ± 0.57 from II to III trimester. The difference in means was statistically insignificant (P > 0.05) (Table No 2) The values were lower in the study group as compared to the control group but were statistically insignificant (P > 0.05) in II trimester and significant (P < 0.05) in III trimester. Probably the lower values may be due to vasodilatation due to hypoxia [12, 13, 15]. Animal experiments and human observations have shown that there is increase in the cerebral blood flow in the growth restricted fetus. This is seen by lower values of pulsatility index. Progressive hypoxia leads to acedemia and there is decreased flow to the brain leading to increased pulsatility index [17, 22].

3.3 Resistance Index (RI)

In the control group the average RI values declines from 0. 82 ± 0.12 to 0.8 ± 0.20 from II to III trimester. The difference in means was statistically insignificant (P > 0.05) (Table No 2)

This decline with the increase in gestational age is due to decrease in vascular resistance so as to meet the oxygen demands of the growing fetus[12,21].

In the study group the average RI values decline from 0.8 ± 0.13 to 0.73 ± 0.15 from II to III trimester (Table No 2) The difference in means was statistically significant (P < 0.05). The values were lower in the study group as compared to the control group. The difference in means was statistically insignificant (P > 0.05) in II trimester but was significant (P < 0.05) in III trimester when compared with the control group. The lower values are due to vasodilatation due to hypoxia in order to supply more blood to the brain to protect it from the damaging effects of hypoxia. Thus the brain is spared from damage [12, 13, 20, 21].

Figure 2 (a) Normal middle cerebral artery waveform pattern showing low end diastolic flow

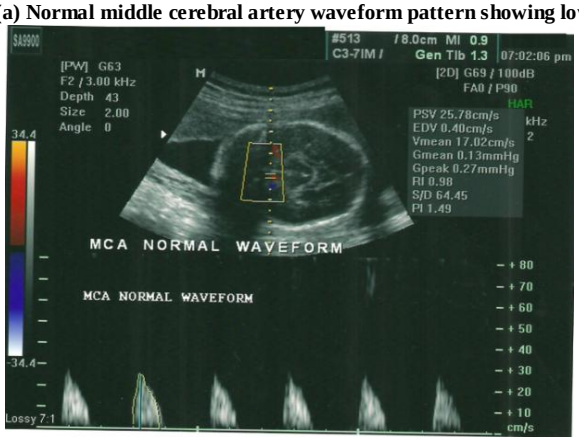
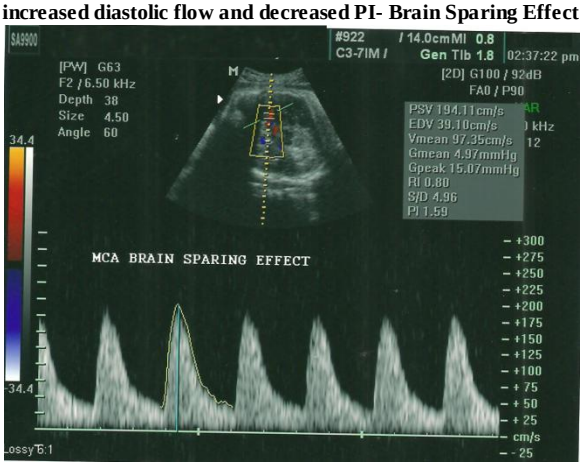


Figure No. 2 (b) Abnormal middle cerebral artery waveform pattern showing markedly increased diastolic flow and decreased PI- Brain Sparing Effect



4. 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.

The abnormal fetal middle cerebral circulation is suggestive of fetal pathology (IUGR).

In the fetal middle cerebral artery in both the control and study groups all the values of S/D, PI and RI decline from II to III trimester. The decline was more and the values were low in the study group as compared to the control group. Lower PI values were suggestive of fetal hypoxia.

Doppler velocimetry can be a useful prenatal test for the patients with intrauterine growth restriction.

Perinatal morbidity and mortality can be reduced by fetal surveillance and Doppler velocimetry study by early intervention.

Thus the Doppler velocimetry is a primary tool for fetomaternal surveillance in IUGR pregnancies. The efficiency of color Doppler velocimetry helps to take timely action, plan the treatment and also counsel the patient in their future pregnancies.

Today the advent of color flow imaging, Doppler and power anio have opened up a new diagnostic horizon for understanding physiology and vascular pathology of Gynaecology, infertility, uteroplacental and fetoplacental circulation.

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