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RESEARCH ARTICLE

Evaluation of fetal middle cerebral artery Doppler indices in pregnancies with intrauterine growth restriction: A cross-sectional study

Padmaja Rajey Desai[1], Sunita Milind Tiwale[1], Pandian Murugesan Devar[1], Rajey M Desai[2]

[1]Department of Physiology, D. Y. Patil Medical College, Kolhapur, Maharashtra, India, [2]Consultant Radiologist, Marvel Diagnostic Center, Kolhapur, Maharashtra, India

Correspondence to: Padmaja Rajey Desai, E-mail: padmajardesai@gmail.com

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ABSTRACT

Background: Doppler velocimetry studies of placental and fetal circulation can provide important information regarding fetal well-being providing an opportunity to improve fetal outcome. **Aims and Objective:** The aim of this study to evaluate the role of color Doppler velocimetry of the fetal middle cerebral artery (MCA) velocity waveforms, systolic/diastolic ratio (S/D), pulsatility index (PI), and resistance index (RI) in intrauterine growth restriction (IUGR) pregnancies in II and III trimesters. **Materials and Methods:** This was a cross-sectional study. The control and study groups were studied in II and III trimesters. They were first subjected to ultrasonography biometry and then to MCA Doppler sonography. The statistical analysis was performed by "unpaired" and "paired" *t*-test. **Results:** In both control and study groups, the values of S/D ratio, PI, and RI in MCA decline during II to III trimester. The values were lower in the study group as compared to the control group. Thus that the present study predicts were; (a) lower PI values were suggestive of fetal hypoxia, (b) The lower values are due to vasodilatation due to hypoxia to supply more blood to the brain to protect it from the damaging effects of hypoxia. Thus, the brain is spared from damage. **Conclusion:** Doppler can be considered as one of the important non-invasive techniques to assess the fetomaternal and uteroplacental circulations. The MCA indices were valuable for predicting the outcome of IUGR pregnancies.

KEY WORDS: Fetal Growth Restriction; Middle Cerebral Artery Doppler Sonography; Perinatal Outcome

INTRODUCTION

Intrauterine growth restriction (IUGR) defined by body mass and weight loss <10th percentile is regarded as dangerous pregnancies due to complications resulted from delivery interventions in mother and later neonatal complications.[1,2] The high-risk pregnancy continues to represent a significant and growing problem in perinatal morbidity and mortality. The development of ultrasound and its application to the obstetrics was 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. At present, 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.[3-8] 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]

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The Doppler effect was described by Austrian Physicist Johann Christian Doppler in 1842.[10] In 1977, the first Doppler ultrasound study of fetus was conducted 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 (MCA).[5-11]

Hence, 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 most common high-risk pregnancy like intrauterine growth restriction (IUGR) is studied.

Objectives

1. Primary objective: To evaluate the role color Doppler velocimetry of the fetal MCA in IUGR pregnancies to determine its predictive value on fetal outcome.
2. Secondary objective: To assess the fetal growth by measuring S/D ratio, PI, and RI in the fetal MCA in the study group by color Doppler velocimetry.

MATERIALS AND METHODS

The present cross-sectional study was conducted in the Department of Physiology, in Dr. D.Y. Patil Medical College, Kolhapur, during January 2016-December 2016. This study was approved by Institutional Ethics Committee. The study was undertaken using a "color Doppler velocimetry" at Marvel Diagnostic Center, Kolhapur. Approval for this work was obtained from the diagnostic center. It is undertaken in the 50 normal pregnant women (control group) and 50 high-risk pregnant women (study group).

Informed consent was taken from each woman included in the control and study groups.

1. The study was conducted in the age group between 20 and 35 years from gravida 1 to 5 in both the control and study groups
2. The women in th control and study groups were examined in II trimester (20-24 weeks) and III 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 (USG) biometrical findings were included in this study.

Pregnant women are having other high-risk factors such as pregnancy-induced hypertension (PIH), polyhydramnios, gestational diabetes, pregnancy with heart disease, and severe anemia of pregnancy were excluded from the study.

The pregnant women in both the groups (control and study) were subjected to USG. 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 USG and then they were subjected to Doppler studies.

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 USG 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.

Doppler Principle[10,12]

The Doppler effects were 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 backscattering 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 follows:

A. Audio signals,
B. Spectral wave forms,
C. Color information,
D. Zero crossing recorders.

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 fetal MCA 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 III trimester.

The Study Group

The same procedure was repeated in II and III trimesters of pregnancy in the study group.

The following values were recorded during the examination of the MCA:

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. S/D ratio
2. PI
3. RI,

With the following formula, the waveforms were analyzed[9,14]

- S/D ratio = (PSV)/(EDV)
- PI = (PSV - EDV)/(Mean velocity)
- RI = (PSV - EDV)/Systolic velocity

All the values of S/D ratio, PI, and RI in the control and study groups were arranged in tabular form and were statistically analyzed by "unpaired" and "paired" *t*-tests. $P < 0.05$ was considered statistically significant. Statistical analysis is performed using SPSS version 23. Numerical data are expressed as mean ± standard deviation.

RESULT

In the control and study groups, 30 cases were having parity 1, 18 cases were having parity 2, 1 case of parity 3, and 1 case of parity 4 (Figure 1).

Table 1 shows that in II trimester, the mean values of S/D ratio are lower in the study group as compared to control group. The difference in means of S/D ratio values between the control and the study groups is statistically insignificant. In the control group, the mean S/D values decline from II to III trimester. The difference in means is statistically insignificant. In the study group, the mean S/D values decline from II to III trimester. The difference in means is statistically insignificant. The mean values of PI are lower in the study group as compared to control group.The difference in means of PI values between the control and the study group is statistically insignificant. In the control group, the mean PI values decline from II to III trimester. The difference in means is statistically insignificant. In the study group, the mean PI values decline from II to III trimester. The difference in means is statistically insignificant. The mean values of RI are lower in the study group as compared to control group.The difference in means of RI values between the control and the study groups is statistically insignificant. In the control group, the mean RI values decline from II to III trimester. The difference in means is statistically insignificant. In the study group, the mean RI values decline from II to III trimester. The difference in means is statistically significant.

In III trimester, the mean values of S/D ratio are lower in the study group as compared to control group. The difference in means of S/D ratio values between the control and the study groups is statistically insignificant. The mean values of PI are lower in the study group as compared to control group. The difference in means of the PI values between the control and the study groups is statistically significant. The mean values of RI are lower in the study group as compared to control group. The difference in means of RI values between the control and study groups is statistically significant.

DISCUSSION

The purpose of the present work was to study the Doppler velocimetry of fetal MCA in the defined high-risk group to determine its predictive value on the fetal outcome. Fetal MCA 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.[11,15-18]

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 II and IIItrimesters of pregnancy.

In the present study, all the values decline gradually with increasing gestational age in both the control and study groups (Table 1). All the values were lower in the study group as compared with the control group.

Table 1: Comparison of average values of S/D, PI, and RI between control and study groups of pregnant women in II and III trimesters in fetal MCA

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

*$P < 0.05$ significant, $P > 0.05$ insignificant, S/D: Systolic/diastolic ratio, PI: Pulsatility index, RI: Residence index, MCA: Middle cerebral artery

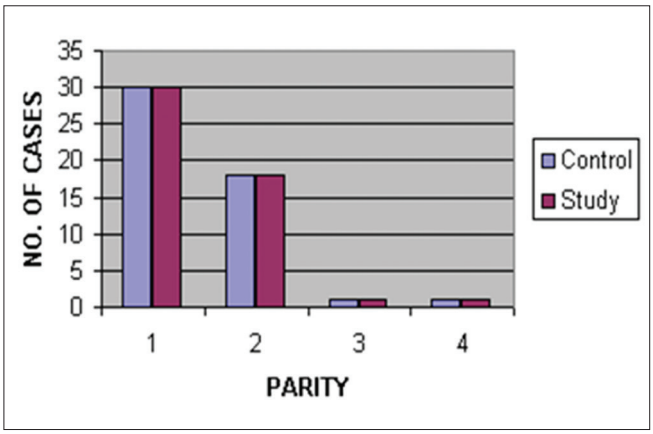

Figure 1: Parity distribution

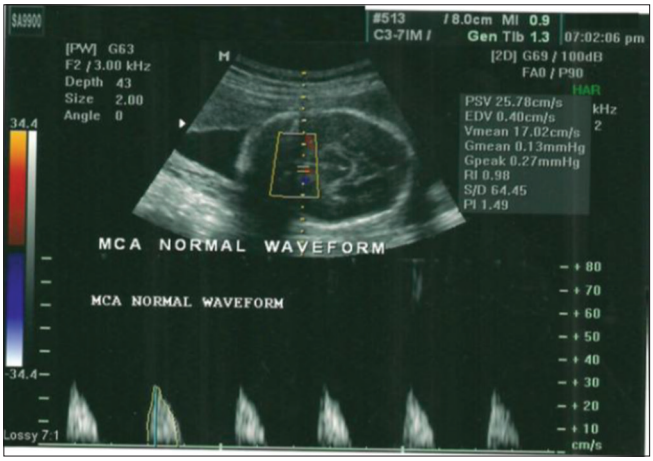

Figure 2: Normal middle cerebral artery waveform pattern showing low end diastolic flow

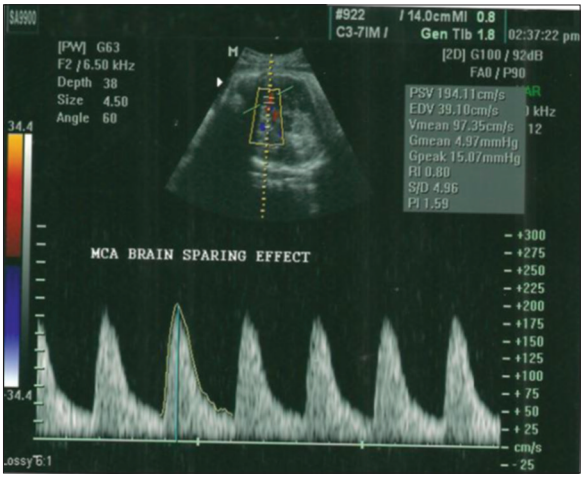

Figure 3: Abnormal middle cerebral artery waveform pattern showing markedly increased diastolic flow and decreased pulsatility index-brain sparing effect

S/D Ratio

In the present study, in the control group, the mean values of S/D ratio decline gradually from II to III trimester (Table 1). The difference in means was statistically insignificant ($P > 0.05$).

(95% confidence interval, range: 2.853-7.753). Probably, the decline in the values with the increase in the gestational age is due to decrease in vascular resistance in the fetal MCA 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 (Figure 2).[12,19]

In the study group, the mean values of S/D ratio decline from II to III trimester (Table 1). The difference in means was statistically insignificant ($P > 0.05$) (95% confidence interval, range: 1.476-6.876). The values were lower in the study group as compared to the control group.

The difference in means was statistically insignificant ($P > 0.05$) (95% confidence interval, range: 5.32-5.64) in II trimester and (95% confidence interval, range: 3.532-4.352) 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 are due to still further fall in peripheral resistance that is occurring due to vasodilatation due to hypoxia and diastolic flow increases (Table 1 and Figure 3). 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]

PI

The PI values in the control group decline from II to III trimester. The difference in means was statistically insignificant ($P > 0.05$) (95% confidence interval, range: 0.1491-0.2491) (Table 1).

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 mean PI values decline from II to III trimester. The difference in means was statistically insignificant ($P > 0.05$) (95% confidence interval, range: 0.1843-0.2643) (Table 1).

The values were lower in the study group as compared to the control group but were statistically insignificant ($P > 0.05$) (95% confidence interval, range: 0.03833-0.3983) in II trimester and significant ($P < 0.05$) (95% confidence interval, range: 0.03556-0.3756) 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 PI. Progressive hypoxia leads to academia and there is

decreased flow to the brain leading to increased PI (Table 1 and Figure 3).[17,22,23]

Resistance Index (RI)

In the control group, the mean RI values decline from II to III trimester. The difference in means was statistically insignificant ($P > 0.05$) (95% confidence interval, range: 0.04546-0.08546) (Table 1).

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 mean RI values decline from II to III trimester (Table 1). The difference in means was statistically significant ($P < 0.05$) (95% confidence interval, range: 0.01429-0.1257). The values were lower in the study group as compared to the control group. The difference in means was statistically insignificant ($P > 0.05$) (95% confidence interval, range: 0.02965-0.06965) in II trimester but was significant ($P < 0.05$) (95% confidence interval, range: 0.0001615-0.1402) in III trimester when compared with the control group. Our findings are similar to Bhatt C.J et al. where lower values are due to vasodilatation due to hypoxia to supply more blood to the brain to protect it from the damaging effects of hypoxia (Table 1 and Figure 3). Thus, the brain is spared from damage.[20-24]

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. Furthermore, abnormality in blood flow indices directly correlates 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 MCA 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 IUGR. 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 gynecology, infertility, and uteroplacental and fetoplacental circulation.

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