Original Research Article

Fetal umbilical artery to middle cerebral artery doppler velocimetry ratio as a predictor for adverse perinatal outcome in high risk pregnancy

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Abstract

Background: Measurement of blood flow velocities in the maternal and fetal vessels provides information about uteroplacental blood flow and fetal responses to physiologic challenges. Doppler assessments of umbiical artery and fetal middle cerebral artery are most useful for monitoring fetuses with early-onset growth restriction and fetal anemia in at-risk pregnancies. **Aim:** To study ratio of middle cerebral to umbilical artery blood velocity in high risk pregnancies to evaluate the role of these blood flow indices in the prediction of adverse foetal outcome. **Material and Methods:** A total of 200 pregnant women with full term pregnancy were included. Doppler velocity waveforms of umbilical and middle cerebral arteries were taken for high risk pregnancies. Abnormal perinatal outcome was measured and correlated. **Results:** Abnormal Ratio of MCA/UC PI was associated with adverse perinatal outcome like thick meconium stained liquor, Apgar < 7 at 5 minutes, respiratory complications within 72 hrs, NICU admission within 72 hours of birth and Small for age. **Conclusion:** Abnormal ratio of MCA/UC PI and RI were found to be associated with adverse perinatal outcome. So, abnormal Doppler velocimetry indices are good predictor for adverse perinatal outcome in high risk pregnancy.

Key Word: High risk pregnancy, umbilical artery, middle cerebral artery, Doppler velocimetry, perinatal outcome

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Email: shrutishah024@gmail.com
Received Date: 21/01/2019 Revised Date: 11/02/2019 Accepted Date: 14/04/2019
DOI: https://doi.org/10.26611/10121028

Access this article online	
Quick Response Code:	Website: www.medpulse.in
	Accessed Date: 07 May 2019

INTRODUCTION

Despite recent advances in antenatal care, preeclampsia remains the major cause of maternal and perinatal morbidity and mortality. So, early screening of preeclampsia and fetal growth restriction may allow vigilant antenatal surveillance and appropriate timing of fetal delivery in order to avoid serious sequelae. It has been long assumed that insufficient uterine, placental, and fetal circulations result in adverse pregnancy outcomes and that those abnormalities can be defined by the use of Doppler ultrasonography.[1] Measurement of blood flow velocities in the maternal and fetal vessels provides information about uteroplacental blood flow and fetal responses to physiologic challenges. Abnormal vascular development of the placenta, such as in preeclampsia, results in progressive hemodynamic changes in the fetoplacental circulation. Doppler indices from the umbilical artery increase when 60 to 70 percent of the placental vascular tree is compromised;[2] eventually, fetal middle cerebral artery impedance falls and fetal aortic resistance rises to preferentially direct blood to the fetal brain and heart.[3,4]Ultimately, end diastolic flow in the umbilical artery ceases or reverses and resistance increases in the fetal venous system (ductus venosus,

How to cite this article: Sanjaya Sharma, Shushila Kharakwa, Shruti Gupta, Prakhar Mohniya. Fetal umbilical artery to middle cerebral artery doppler velocimetry ratio as a predictor for adverse perinatal outcome in high risk pregnancy. *MedPulse International Journal of Gynaecology*. May 2019; 10(2): 53-58. http://medpulse.in/Gynacology/index.php

inferior vena cava).[5-8] Umbilical artery Doppler assessments are most useful for monitoring fetuses with early-onset growth restriction due to uteroplacental insufficiency.[9] Doppler assessment of the fetal middle cerebral artery-peak systolic velocity is the best tool for monitoring for fetal anemia in at-risk pregnancies, such as those affected by Rhesus alloimmunization. With these background, the present research was conducted to study ratio of middle cerebral to umbilical artery blood velocity in high risk pregnancies to evaluate the role of these blood flow indices in the prediction of adverse foetal outcome.

MATERIAL AND METHODS

This observational descriptive follow up study was conducted in the Department of Radio Diagnosis and Imaging a tertiary care hospital over a period of two years. The study was conducted among pregnant women with full term pregnancy. All pregnant women underwent Doppler Velocimetry of umbilical and middle cerebral arteries

Sample size: Considering the feasibility and study period, a sample size of 200 case with high risk pregnancy fulfilling eligibility criteria was decided.

Sampling technique: All cases diagnosed having high risk pregnancy and fulfilling the inclusion and exclusion criteria from in the OPD of Department of Obstetrics and Gynecology and subsequently referred to radiology department for Doppler were included in the study. This was continued till the desired sample size of 200 cases achieved.

Inclusion criteria

- Full term pregnant women
- Well documented length of pregnancy
- Singleton pregnancy
- Gestational age beyond 30 weeks.
- High risk factors considered were - pre-eclampsia, intra uterine growth restriction, gestational diabetes mellitus, anemia, previous Ceaserean section, bad obstetric history, Rh isoimmunisation and twin pregnancy.

Exclusion criteria

- Threatened preterm labour
- Wrong dates
- Fetus with congenital anomaly
- Intrauterine death at the time of Doppler.
- Not willing to participate

Abnormal Perinatal Outcome

The perinatal outcome was considered abnormal when any one or combinations of the following are present.

- Perintatal death
- Thick meconium stained liquor
- Apgar < 7 at 5 minutes
- Respiratory complications within 72 hours of birth
- NICU admission within 72 hours of birth.

Doppler velocity waveforms of umbilical and middle cerebral arteries were taken for high risk pregnancies. A colour Doppler ultrasound apparatus (LOGIC 400 PRO-GE series) equipped with 3.75 MHz transducer was used for the Doppler study. All the examinations were made with the patient lying in semi recumbent position with a lateral tilt. Doppler transducer was placed on the abdominal wall over the uterus and carefully manipulated till Doppler signals appropriate for those particular vessels were identified. All the examinations were performed only during foetalapnoea and foetal inactivity. The signal was recorded for a minimum of 5 to 8 cycles with blood flow velocity waveforms of equal shape and amplitude and satisfactory quality. Then the image was frozen and measurements was taken.

Table 1: Normal values of Doppler Velocimetry [30th week – 40th week of pregnancy]

Doppler Velocimetry	S/D ratio	P.I.	R.I.
Umbilical artery	≤3	0.7 – 1.4	0.5 – 0.7
Middle Cerebral Artery	> 4	> 1.3	0.7
Ratio of Middle Cerebral Artery RI / Umbilical Artery	-	-	> 1

S/D = maximum peak Systolic frequency / end – Diastolic velocity; P.I.= Pulsatility index; R.I. = Resistance Index.

With the following formula the wave forms were analyzed

1. Systolic / Diastolic Ratio (S/D) = Peak systolic velocity /End diastolic velocity
2. Pulsatility Index (PI) = Peak systolic velocity – End diastolic velocity/Mean velocity
3. Resistance Index (RI) = Peak systolic velocity – End diastolic velocity/Systolic velocity

Ethical consideration: Once the case was found eligible for the study, she was informed about the study procedure. Potential risk and benefit of the study were informed to each patient. Patient was also informed about their write to withdrawal from the study at any point of time. She was also assured about equal quality of care from the hospital even in case of withdrawal or denial from participation in the study. After that a written consent was taken in vernacular language. In cases of illiterate patients, consent was taken in presence of witness. All the information collected from the patients and clinical findings were kept confidential. At the time of writing results all necessary care was taken to avoid

individual cases identifier. Data were presented as aggregate and not as individual case.

Statistical Analysis: All information collected from the patients were entered in the computer using Microsoft excel. Data were analysed using epi-info software. All qualitative data were presented in form of frequency and percentage. All quantitative data were presented in form of mean and standard deviation. Chi-square test applied to calculate statistical association between two qualitative variables. P value <0.05 was considered as statistical significance at 95% confidence interval.

RESULTS

This study was conducted among 200 high risk mother to study the Systolic/ Diastolic ratio (S/D ratio), pulsatility index (PI) and resistance index (RI) of umbilical artery and middle cerebral arteries. Out of 200 mothers, 169 (84.5%) were less than 30 year of age while remaining 31 (15.5%) were above 30 year of age.87 (43.5%) were primi gravida while remaining 113 (56.5%) were multi gravida. Out of 200 mothers, 154 (77.0%) were full term while remaining 46 (23%) were preterm deliveries. For Umbilical Artery the mean S/D ratio was 2.543, mean Pulsatility Index was 0.576 and mean Resistance Index was 0.569.For Middle Cerebral Artery (MCA) the mean S/D ratio was 5.940, mean Pulsatility Index was 1.428 and mean Resistance Index was 0.659.For MCA/UC the mean Pulsatility Index was 0.893 and mean Resistance Index was 1.119.For Umbilical Artery abnormalS/D ratio was found in 40 cases (20%), abnormal Pulsatility Index was found in 53 (26.5%) and abnormal Resistance Index was found in 58 (29%).

Table 2: Normal and Abnormal Doppler variables for Ratio of MCA / UA

Doppler variables	Ratio of MCA / UA			
	Normal	%	Abnormal	%
Pulsatility Index	157	78.5	43	21.5
Resistance Index	148	74.0	52	26.0

Table 2 shows various abnormal and normal Doppler variables of Middle Cerebral Artery. For Middle Cerebral ArteryabnormalS/D ratio was found in 28 cases (14%), abnormal Pulsatility Index was found in 8 (4%) and abnormal Resistance Index was found in 11 (5.5%). For Ratio of MCA / UA abnormal Pulsatility Index was found in 43 (21.5%) and abnormal Resistance Index was found in 52 (26%).

Table 3: Perinatal outcome according to Ratio of MCA/UC PI

Perinatal Outcome	Ratio of MCA/UC PI				P value
	Normal	%	Abnormal	%	
Total subject (n)	157	100.0	43	100.0	-
Adverse perinatal outcome	10	6.4	43	99.3	<0.01*
Thick meconium stained liquor	3	1.9	37	85.5	<0.01*
Apgar < 7 at 5 minutes	3	1.9	24	55.4	<0.01*
Respiratory complications within 72 hrs	10	6.4	30	69.3	<0.01*
NICU admission within 72 hours of birth	10	6.4	30	69.3	<0.01*
Perintatal death	0	0.0	3	6.9	-
Small for age	57	36.4	27	62.4	<0.01*

*P <0.05 indicate statistical significance.

Table 3 shows perinatal outcome according to ratio of MCA/UC PI. Abnormal Ratio of MCA/UC PI was associated with adverse perinatal outcome like thick meconium stained liquor, Apgar < 7 at 5 minutes, respiratory complications within 72 hrs, NICU admission within 72 hours of birth and Small for age.

Table 4: Perinatal outcome according to Ratio of MCA/UC RI

Perinatal Outcome	Ratio of MCA/UC RI				P value
	Normal	%	Abnormal	%	
Total subject (n)	148	100.0	52	100.0	-
Adverse perinatal outcome	13	8.8	40	76.9	<0.01*
Thick meconium stained liquor	3	2.0	37	71.2	<0.01*
Apgar < 7 at 5 minutes	0	0.0	27	51.9	<0.01*
Respiratory complications within 72 hrs	13	8.8	27	51.9	<0.01*
NICU admission within 72 hours of birth.	10	6.8	30	57.7	<0.01*
Perintatal death	0	0.0	3	5.8	-
Small for age	57	38.5	27	51.9	0.09

*P <0.05 indicate statistical significance.

Table 4 shows perinatal outcome according to Ratio of MCA/UC RI. Abnormal Ratio of MCA/UC RI was associated with adverse perinatal outcome like thick meconium stained liquor, Apgar < 7 at 5 minutes, respiratory complications within 72 hrs, NICU admission within 72 hours of birth and Small for age.

DISCUSSION

The introduction of Doppler velocimetry to obstetrics provides a non-invasive method of indirectly assessing uteroplacental and the fetal circulation. Umbilical artery Doppler velocimetry was first examined as a potential means of monitoring fetal compromise. Increasingly, however, consideration is being paid to the modifications in the circulation within the fetus as a means of deciding other alterations that might reflect intrauterine compromise. Studies of the correlation between Doppler of the umbilical arteries and gases in umbilical venous blood have concluded that alterations occurred in circulation preceded the onset of hypoxia.[10,11] These diversifications are likely to be subtle in the initial phases and therefore less likely to be identified from single artery Doppler velocimetry. Different attempts have therefore been made to study multiple vessels to improve identification of the compromised fetus.[12] In the present study for Umbilical Artery the mean S/D ratio was 2.543, mean Pulsatility Index was 0.576 and mean Resistance Index was 0.569. For Middle Cerebral Artery (MCA) the mean S/D ratio was 5.940, mean Pulsatility Index was 1.428 and mean Resistance Index was 0.659. For the ratio of MCA/UC the mean Pulsatility Index was 0.893 and mean Resistance Index was 1.119.In a study by Davies JA *et al*[13] for Umbilical Artery the mean S/D ratio, Pulsatility Index and Resistance Index were 2.58, 0.68 and 0.66 respectively. For Middle Cerebral Artery (MCA)S/D ratio, Pulsatility Index and Resistance Index were 6.23, 1.13 and was 0.75 respectively. For the ratio of MCA/UC the mean Pulsatility Index was 0.94 and mean Resistance Index was 1.21.In a study by Malik R *et al*[14]Umbilical Artery the mean S/D ratio was 2.26, mean Pulsatility Index was 0.498 and mean Resistance Index was 0.642. For Middle Cerebral Artery (MCA) the mean S/D ratio was 6.468, mean Pulsatility Index was 1.834 and mean Resistance Index was 0.583. For the ratio of MCA/UC the mean Pulsatility Index was 0.953 and mean Resistance Index was 1.33. In the present study, umbilical artery abnormal S/D ratio was found in 40 cases (20%), abnormal Pulsatility Index was found in 53 (26.5%) and abnormal Resistance Index was found in 58 (29%). For Middle Cerebral Artery abnormalS/D ratio was found in 28 cases (14%), abnormal Pulsatility Index was found in 8 (4%) and abnormal Resistance Index was found in 11 (5.5%). Ratio of MCA/UA abnormal Pulsatility Index was found in 43 (21.5%) and abnormal Resistance Index was found in 52 (26%). In a study by Sharma U *et al*,[15]S/D ratio, Pulsatility Index and Resistance Index of the umbilical artery showed significantly higher indices in the high risk pregnant women ($p<0.001$). This indicated increased peripheral resistance and consequently lower diastolic flow leading to fetal compromise. In the present study, lower birth weight is associated with abnormal S/D ratio and abnormal Resistance Index of umbilical artery. Lower birth weight is associated with abnormal S/D ratio, abnormal pulsatility index and abnormal Resistance Index of middle cerebral artery. Lower birth weight is also associated with abnormal pulsatility index and abnormal Resistance Index of Ratio of MCA / UA. Doppler velocimetry is the best tool of surveillance for fetal hypoxemia in high risk pregnancy.[14]This method is a non-invasive technique for assessing fetal circulation. Its values provide very important information on the hemodynamics of the vascularity of fetal blood vessels. Umbilical and Middle cerebral arteries are commonly assessed vessels for this. Middle cerebral artery doppler measurement is a very well-known modality for diagnosing fetal compromise.[14] In a study by Sumangali PK *et al*,[16] 180 pregnant patients with high risk factors were evaluated by Doppler flow velocimetry of Middle cerebral Artery and umbilical artery by calculating S/D ratio, Resistance indices and Pulsatility indices. In this study PI, RI, S/D ratio, all indices showed progressive fall with advancing gestation in normal pregnant women suggestive of diminish in peripheral impedance and increase in diastolic flow with progression of gestation in both the arteries, umbilical artery as well as Middle cerebral artery. Arduini and Rizzo in an observational cross-sectional study of four fetal vessels found that a combination of the middle cerebral and umbilical artery Doppler velocimetry indices to produce ratios gave the best method of predicting perinatal outcome.[17] They finally concluded that these ratios predicted hemodynamic changes in fetus better than single vessel Doppler indices. So, combining umbilical artery Doppler velocimetry parameters with middle cerebral artery Doppler velocimetry indices would reflect the best way of showing fetal compromise at the earliest and monitoring any high risk pregnancies regularly. In a study by Sumangali PK *et al*[16]they found correlation of adverse fetal outcome with S/D ratio, Resistance indices and Pulsatility indices of umbilical artery and Middle cerebral Artery. Abnormal Ratio of MCA/UC PI and RI were associated with adverse perinatal outcome like thick meconium stained liquor, Apgar < 7 at 5 minutes, respiratory complications within 72 hrs, NICU admission within 72 hours of birth and Small for age.In a study by Sumangali PK *et al*,[16] abnormal MCA/UA Doppler ratio

is strongly associated with worse fetal prognosis. Mikovic *et al*,[18] in their study found that in the high risk group having abnormal Doppler indices, the average (SD) birth weight was 1327+ 245gm, neonatal mortality rate 8.6%, while perinatal mortality rate was 14.3%. A study by Sumangali PK *et al*,[16] found that abnormal MCA/UA Doppler ratio is strongly associated with worse fetal prognosis. Fetuses having abnormal Doppler velocimetry had a statistically significant higher incidence of low birth weight, preterm birth, and admission to NICU. Late onset SGA fetuses with normal Doppler velocimetry indices on diagnosis show progression from 37 weeks gestation with the adversely progressing uteroplacental ratio followed by a lowering of MCA pulsating index(PI). There was more number of NICU admission in abnormal Doppler indices in various studies.[19,20] Our study shows that Doppler study found very useful in predicting perinatal outcome. A study by Sumangali PK *et al*,[16] also showed that the Doppler study in 3rd trimester is very useful in predicting the fetal outcome in high risk pregnancy. Abnormal arterial Doppler is definitely associated with an adverse perinatal outcome need immediate delivery. Doppler data merged both umbilical and cerebral velocimetry provide additional information on fetal consequences of the placental abnormality. Abnormal MCA/UA PI Doppler ratio was strongly correlated with worse fetal prognosis and outcome. In normal pregnancies, the diastolic component in the cerebral arteries is lesser than in the umbilical arteries at any gestational age. Therefore, the cerebro-vascular resistance remains higher than the placental resistance and the MCA/UA ratio is greater than 1. The index becomes less than 1 if the flow distribution is in favor of the brain in pathological pregnancies. Deora R *et al*[21] observed reduction in placental perfusion and an augmented in flow towards the brain. This phenomenon called the brain sparing effect. This effect is supposed to recompense for fetal hypoxia and is associated most of the time with fetal growth retardation with lower umbilical artery pH. The cerebrovascular index decreases progressively, as in the normal fetuses so the hypoxia to be compensated by the brain hyperperfusion.

CONCLUSION

In high risk pregnancy, abnormal Doppler velocimetry indices of Umbilical artery predict adverse perinatal outcome like thick meconium stained liquor, Apgar < 7 at 5 minutes, respiratory complications within 72 hrs, NICU admission within 72 hours of birth and Small for age. Similarly, abnormal S/D ratio, PI and RI of middle cerebral artery also predict adverse perinatal outcome. Abnormal Ratio of MCA/UC PI and RI were associated with adverse perinatal outcome. So, abnormal Doppler velocimetry indices are good predictor for adverse perinatal outcome in high risk pregnancy.

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Source of Support: None Declared
Conflict of Interest: None Declared