Original Article

Middle Cerebral Artery Doppler Indices Better Predictor for Fetal Outcome in IUGR

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Abstract :

Objective(s) : To compare the role of middle cerebral artery and umbilical artery Doppler pulsatility indices in predicting the fetal outcome in intrauterine growth restriction. **Method(s) :** The prospective study was conducted on 121 subjects. They were divided into two groups. The study group (n=71) consists of high risk group of pregnant women with growth restricted fetuses. The control group (n=50) consists of pregnant women with healthy fetuses. Both the groups were evaluated by middle cerebral artery and umbilical artery velocimetry between 28 and 41 weeks of pregnancy. **Results :** Mothers with abnormal velocimetry had more number of cesarean sections to prevent fetal distress than those with normal velocimetry. The subjects with high risk factors had more number of abnormal waveforms than those without high risk factors. The predictive value of Doppler P.I for detecting abnormal fetal outcome was 94% in middle cerebral artery as against 83% for umbilical artery. The sensitivity was 71% for middle cerebral artery versus 44% for umbilical artery. **Conclusion :** Growth restricted fetuses with normal flow velocimetry are at a lower risk than those with abnormal velocimetry in terms of poor Apgar score and neonatal intensive care admission. The average birth weight of the neonates with abnormal Doppler studies was lower as compared to that of neonates with normal velocimetry. Thus middle cerebral artery doppler indices were a better predictor for fetal outcome in IUGR when compared with umbilical artery in terms of sensitivity and predictive value.

Keywords : middle cerebral artery, umbilical artery, intrauterine growth restriction pulsatility index, doppler ultrasonography.

Introduction

Intrauterine growth restriction is the common clinical sign of chronic fetal hypoxemia. It is difficult to differentiate between suboptimal fetal growth due to intrauterine starvation and adequate growth of a constitutionally small infant. Umbilical and middle cerebral artery velocimetry is a good predictor of growth restricted fetus at risk of antenatal compromise^{1,2,3}.

Detecting the fetus with pathological growth restriction that is at risk for perinatal complications has been an ongoing challenge in obstetrics. Study of Doppler velocimetry is also useful in high risk pregnancies with oligohydramnios and fetal growth retardation⁴.

Material and Methods

The study population consisted of 121 women with singleton pregnancies with small for gestational age fetuses (birth weight less than 10th percentile of gestational age) in the year 2005-06 in our hospital. They were referred from peripheral hospitals, from the inpatient ward as well as outpatient department. These women underwent antenatal Doppler examination of umbilical artery between 28 and 41 weeks of gestation.

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The diagnosis of growth restriction in these fetuses depended on ultrasonographic assessment of fetal growth with amniotic fluid index and birth record. Gestational age was established by menstrual history and ultrasonographic assessment prior to 22 weeks of gestation. The ultrasonographic evaluation excluded fetal congenital anomalies.

The fetal biometry included assessment of biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL). Fetal weight was estimated according to Hadlock formula. Amniotic fluid index (AFI) was calculated by adding the vertical depth of the largest pocket in each of the four quadrants. Oligohydramnios was considered when AFI was less than five. Congenitally malformed fetuses detected antenatally or at birth were excluded from the study. Pulsed wave Doppler ultrasound examination of the middle cerebral artery and umbilical artery were performed using color Doppler (Shimadzu SDU 220 color Doppler ultrasound unit with 2-5.5 mHz multifrequency Doppler probe).

The middle cerebral artery is visualized in a transverse axial view of the fetal head at a slightly caudal plane than one used for biparietal diameter measurements

which were made from the middle section of middle cerebral artery. The umbilical artery was identified and flow velocity waveforms were obtained from free floating loop of the cord. No waveforms were recorded during the periods of fetal breathing and body movements. The pulsatility indices of the middle cerebral artery and umbilical artery were recorded. All Doppler recordings were performed by an expert sonologist. The patients with decreased middle cerebral artery PI and absent or reversed diastolic flow in umbilical artery were admitted for further evaluation and delivery. Conservative treatment that was offered to the patients in the hospital with low end diastolic velocimetry consisted of bed rest, daily fetal movement count (DFMC), non stress test and biweekly amniotic fluid estimation. The following criteria were considered for decision regarding delivery – 1. Absent diastolic or reversal of diastolic flow. 2 Abnormal fetal heart tracing. 3. Worsening of maternal condition, eg. preeclampsia. 4. Gestational age of more than 34 weeks in patients with high resistance diastolic flow. 5. Severe fetal growth restriction with AFI less than five.

Steroids were administered as a single dose to all the women between 28 and 34 weeks to enhance fetal lung maturity. Induction of labor was performed with

Table 1
Distribution of cases according to risk factors

S. No	Risk factors	No. of cases	Percentage
1.	Pregnancy induced hypertension (PIH)	17	23.94
2.	Previous IUGR	10	14.08
3.	Anemia	9	13.00
4.	Recurrent abortion	7	9.30
5.	Breech	5	7.04
6.	Primary infertility	4	5.63
7.	Essential hypertension	3	4.23
8.	Previous still birth	3	4.23
9.	Antepartum hemorrhage	3	4.23
10.	Rh negative	2	3.00
11.	Heart disease	2	3.00
12.	Diabetes	1	1.41
13.	Jaundice	1	1.41
14.	Pyrexia	1	1.41
15.	UTI	1	1.41
16.	Cord around neck	1	1.41
17.	Chicken pox	1	1.41
	Total	71	100.0

Table 2

**Distribution of cases according to P.I. values detected
in the middle cerebral artery and umbilical artery**

S. No	Pulsatility index	MCA		UA	
		No.	%	No.	%
1.	Normal	58	78.87	42	59.15
2.	Decrease	13	18.30	-	-
3.	Increase	-	-	29	40.85
	Total	71	100	71	100

Z = 4.358, P < 0.01, Highly significant

Table 3

**Fetal outcome in relation to abnormal umbilical and
middle cerebral artery indices**

S. No.	Doppler indices(PI value)	No. of cases	Mode of delivery	NICU admissions
1.	Abnormal umbilical artery flow	36	a. Vaginal delivery – 14 b. Cesarean section – 22	28
2.	Abnormal middle cerebral artery flow	13	a. Vaginal delivery – 5 b. Cesarean section – 8	10
3.	Normal umbilical artery flow	35	a. Vaginal delivery – 19 b. Cesarean section – 16	3
4.	Normal middle cerebral artery flow	58	a. Vaginal delivery – 28 b. Cesarean section – 30	23

NICU – Neonatal intensive care unit

prostaglandin E₂ gel or oxytocin if spontaneous labor did not start in those women planned for vaginal delivery. If fetal distress developed in these women or those going into spontaneous labor developed fetal distress, emergency cesarean section was done. Elective cesarean section was done for associated obstetric indications. Data collected included elective cesarean section rate, emergency cesarean section rate, normal or induced vaginal delivery rate, gestational age at delivery, birth weight, apgar scores and admission to

neonatal intensive care unit. 'Z' test was applied for statistical purpose.

Results :

Total number of live births in our institute from May 2005 to October 2006 was 4086. Total number of intrauterine growth retarded neonates was 1441. Thus the incidence of IUGR was found to be 15.6% per annum. There was a trend for more underlying medical

Table 4
Cases according to mode of delivery

S. No.	Mode of delivery	Cases		Controls	
		No.	%	No.	%
1.	LSCS - Elective	19	22	4	8
	- Emergency	19	22	8	16
2.	Normal labor	19	22	29	58
3.	Cerviprime induced	07	25	5	9
4.	Breech	3	5	1	2
5.	VBAC	2	2	3	7
6.	Forceps	2	2	-	-
	Total	71	100	50	100

VBAC – Vaginal birth after cesarean section

Table 5
Predictive value of Doppler for detecting abnormal fetal outcome

Doppler indices	No. of findings				Sensitivity a/(a+c)	Specificity d/(b+d)	Predictive value	
	TP	FP	TN	FN			Positive a/(a+b)	Negative d/(c+d)
Middle cerebral artery	32	2	13	24	71%	92%	94%	65%
Umbilical artery	29	5	31	6	44%	61.5%	83%	20%
Both arteries	32	5	24	10	57%	67%	87%	29%

problems in mothers with abnormal Doppler studies. They had high incidence of pregnancy induced hypertension, diabetes mellitus and severe anemia developing during the pregnancy. Oligohydramnios was associated with pregnancy induced hypertension which constituted 23.94% of the cases with abnormal Doppler studies (Table 1). Sixty eight newborns have been found to have birth weight of less than 2.5 kg whereas two newborns were found to have birth weight of 2.5 kg or more. Thirteen of the 71(18.3%) pregnancies with low birth weight had abnormal Doppler waveforms in the middle cerebral artery and 36 of the 71(50.7%) pregnancies with low birth weight had abnormal

waveforms in the umbilical arteries (Table 2). Doppler waveform of the middle cerebral artery was considered abnormal when the PI was reduced in value indicating brain sparing effect and that of the umbilical artery was considered abnormal if the S/D ratio was equal to or more than three or diastolic flow was absent or reversed in fetuses above the gestational age of 28 weeks. Thirty four (47.8%) fetuses had reduced end diastolic velocity, two fetuses (2.8%) had absent end diastolic velocity and one (1.4%) had reversed end diastolic flow. Small for gestational age babies with abnormal waveforms are at an increased risk for oligohydramnios and for delivery at a lower gestational age. Frequently the

fetuses in the abnormal Doppler group were delivered by cesarean section than those with normal velocimetry. These neonates had lower birth weight percentile with higher birth asphyxia in terms of lower Apgar score which was below seven at birth and were more than twice as likely to be admitted in neonatal intensive care unit (Table 3).

Discussion :

Doppler velocimetry identifies normal and altered blood flow velocity in the middle cerebral artery and umbilical artery and is responsive to changes in placental resistance. It has been shown by various workers⁵ that perinatal morbidity and mortality were significantly greater in small for gestational age babies with abnormal Doppler than in those with normal studies. Serial Doppler ultrasonography in a severely growth-restricted fetus revealed progressive reduction in pulsatility index of the middle cerebral artery, consistent with brain-sparing effect. At 29 weeks, one week before fetal death, the pulsatility index in the middle cerebral artery returned to normal values and became reversed the day before the fetal death. This report suggests that the reverse flow in the middle cerebral artery is one of the terminal hemodynamic events preceding fetal death⁶.

Out of 144 examinations, on 16 occasions, the middle cerebral artery could not be evaluated on first attempt, because of either fetal position or fetal movement. One SGA fetus studied, presented head and abdominal circumference below their reference range, the pregnancy was complicated by oligohydramnios. This fetus had reverse flow in the umbilical artery, and fetal demise was diagnosed four weeks later³. All the fetuses estimated to be SGA in utero turned out to be SGA at birth. In nine SGA fetuses, the middle cerebral artery was below their normal reference range, two of these died in utero; one died soon after birth; five had fetal distress or were admitted to neonatal intensive care unit and one was normal. In two fetuses that died in utero the time between the study of the middle cerebral artery and the fetal demise ranged from 2 to 4 weeks. The MCA PI was reduced in four out of the five perinatal deaths indicating high sensitivity rate of MCA PI in detecting adverse perinatal outcome (80%). Mean PI of the internal carotid artery ranged between 1.5-1.6 and the umbilical artery between 0.7-1.3. The latter difference is statistically significant ($P=0.001$). PI value of the IUGR group was compared to the PI values of the normal

population. The most striking feature was the marked reduction of the PI in the internal carotid artery with a concomitant rise in the umbilical artery⁷. In our study (Table 2), PI value of the middle cerebral artery was found to be normal in 56 cases and less than normal in 15 cases ($P<<0.01$, highly significant). The PI value of the umbilical artery was found to be normal in 42 cases and increased in 29 cases suggesting absent or decreased diastolic flow in umbilical artery ($P<0.001$, highly significant). This corroborates with the study done by other authors.

When used for the prediction of adverse perinatal outcomes, absent or reversed end-diastolic Doppler flow of the umbilical artery (used as a categorical variable) and that of an abnormal middle cerebral artery have the sensitivity, specificity, positive predictive value and negative predictive value as in Table 6. Distribution of the cases according to mode of delivery as seen in Table 4 shows more number of cesarean sections (44%) were done in cases when compared to controls (24%). More number of normal labor, vaginally delivered (58%) was found in controls than in cases (26.7%). Equal number of elective and emergency cesarean sections was done in cases. Most common indication of LSCS was fetal distress, IUGR and oligohydramnios. Various studies have reported on the association of abnormal velocity waveforms with fetal growth restriction and its prediction. All the infants whose birth weight is below the 10 percentile are not exposed to a pathologic process in utero but some are constitutionally small and healthy. Meta analysis of Doppler ultrasonography in high risk pregnancies with IUGR has revealed a statistically significant improved perinatal outcome. The results shown in Table 3 reveal that more number of cesarean sections were performed in abnormal umbilical artery flow (22) and in normal middle cerebral artery flow (30) indicating the brain sparing effect of middle cerebral artery. There were increased NICU admissions (28) in abnormal umbilical artery flow and (23) in normal middle cerebral artery flow. Various workers have noticed in fetuses with abnormal Doppler velocimetry a similar poor perinatal outcome. There are old reports suggesting the Doppler studies of velocity waveform being more useful in identifying fetuses prone for IUGR than sonographic estimation of fetal weight^{8,9}. Mothers of small for gestational age babies with abnormal Doppler velocimetry frequently delivered by cesarean section for fetal distress and were less likely to undergo induction of labor than those with normal Doppler.

Table 6
Comparative predictive value of middle cerebral artery for detecting abnormal fetal outcome

Study	Year	Artery	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Mari G. et al ³	1992	Middle cerebral	60	87	67	83
Trudinger BJ et al ⁸	2005	Middle cerebral	35	56	35	56
		Umbilical artery	34	93	75	70
		Cerebro-placental Doppler ratio	65	73	73	65
Present study (Table 5)	2006	Middle cerebral	71	92	94	65
		Umbilical artery	44	61.5	83	20

There was still a higher incidence of cesarean section rate for fetal distress in the group with absent diastolic flow and with CPR of less than 1.08 (an abnormal CPR). Doppler of velocimetry studies of middle cerebral artery can provide the obstetrician important information regarding fetal wellbeing to help him improve fetal outcome. Predictive value of Doppler for detecting abnormal fetal outcome is seen in Table 5. The positive predictive value of middle cerebral artery in detecting abnormal fetal outcome was found to be 94%, specificity of middle cerebral artery was found to be 94%, sensitivity 71% and negative predictive value 65%. Fleischer et al⁹ have pointed out the role of venous doppler studies in assessing the degree of hypoxemia and in guiding the correct time of delivery. Middle cerebral artery flow velocimetry studies should be an integral parameter while evaluating in utero health of the growth restricted fetuses. This may help to improve pregnancy management and identification and assessment of IUGR at earliest gestational age as compared to other antepartum test modalities which will help in early intervention and therapy. This helps to improve maternal well being and fetal health.

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