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ORIGINAL ARTICLE

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Significance of umbilical artery velocimetry in perinatal outcome of growth restricted fetuses

Arora *Devendra*, Desai *Sadhana K*, Sheth *Prem N*, Kania *Prema*

Bombay Hospital Institute of Medical Sciences and Post Graduae Research, Mumabi.

OBJECTIVE(S) : To study pregnancy outcomes in growth restricted fetuses with normal umbilical artery velocimetry, low-end diastolic umbilical flow, and absent or reversed diastolic flow.

METHOD(S) : One hundred and thirty-four pregnant women with growth-restricted fetuses were evaluated by umbilical artery velocimetry between 28 and 41 weeks of pregnancy. Outcome of pregnancy was recorded for the normal doppler group (n=90; 69.5%), the low-end diastolic flow group (n=30; 20.5%) and the group with absent / reversed diastolic flow (n=14; 10%).

RESULTS : Fetuses with abnormal umbilical flow velocimetry had higher incidence of oligolydramnios and abnormal NST compared to fetuses with normal umbilical flow. The average birth weight, diagnosis to delivery interval, and gestational age at delivery were comparatively lower with higher incidence of admission to neonatal intensive care unit in fetuses with abnormal umbilical doppler velocimetry. There was no perinatal death in the study.

CONCLUSION(S) : Growth restricted fetuses with normal umbilical flow velocimetry are at a lower risk than those with abnormal velocimetry in terms of poor apgar score, and neonatal intensive care admission and its duration. The need for positive pressure ventilation at birth was more in babies with absent diastole / reversed diastolic flow of umbilical artery velocimetry. The average birth weight of the neonates with abnormal umbilical artery doppler was lower of compared to that of neonates with normal umbilical artery velocimetry. The poor neurological sequelae were noticed in neonates with absent diastole / reversed diastolic flow after 6 months follow up.

Key words : intrauterine growth restriciton, doppler, umbilical artery velocimetry

Introduction

Intra-uterine growth restriction is a common clinical sign of chronic fetal hypoxemia. It is difficult to differentiate between suboptimal fetal growth due to intra-uterine starvation and adequate growth of a constitutionally small infant. Umbilical artery velocimetry is a good predictor in these growth-restricted fetuses at risk of antenatal compromise [1,2]. Detecting the fetus with pathological growth restriction that is at risk for perinatal complications has been an ongoing challenge in obstetrics. Study of umbilical flow velocimetry is also useful in high-risk pregnancies with oligohydraminos and fetal growth retardation except those with premature rupture of the membrane or renal defects [3].

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Correspondence :
Dr. Arora Devendra
C-12, Rajaji Puram, Talkatora Road,
Lucknow - 226017. (UP)

Material and Methods

The study population consisted of 134 women who had delivered singleton pregnancies with small for gestational age fetuses (birth weight less than 10th percentile for gestational age) in the year 2002 at our hospital. They were referred from the peripheral hospitals and by the obstetricians from the in-patient ward as well as outpatient department. These women underwent antenatal doppler examinations of umbilical artery between 28 and 41 weeks of gestation. 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 femoral length (FL). Fetal weight was estimated according to the Hadlock formula that uses FL, AC and BPD. Amniotic fluid index (AFI) was calculated by adding the vertical depths of the largest pocket in each of the four uterine quadrants. Oligohydramnios was considered when AFI was nine or less without premature rupture of membranes. Congenitally malformed fetuses detected antenatally or at birth were excluded from the study.

Pulsed wave doppler ultrasound examination of the umbilical artery was performed using color doppler (GE 700 MR with 3.5 MHz curvilinear transducer). The umbilical artery was identified and flow velocity waveforms were obtained from free-floating loop of cord. Recordings were accepted for analysis only after a clear steady state was obtained for at least two consecutive pulsatile waveforms. No waveforms were recorded during periods of fetal breathing and body movements. The systolic/ diastolic (S/D) ratio of the umbilical artery and absence or reversal of end diastolic velocity were noted. The angle between the ultrsound beam and the direction of the blood flow was less than 35 degrees.

For the purpose of analysis, the study population was distributed in three groups: a normal doppler group, a diminished end-diastolic flow group and, an absent diastole or reversed diastolic flow group. All doppler recordings were performed by an expert sonologist. doppler examinations were repeated weekly or biweekly according to the severity of the reduction of the end diastolic flow in the umbilical artery. Patients with S/D ratio equal to or more than three, and those with absent diastole or reversed diastolic flow 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, nonstress test, and biweekly amniotic fluid estimation. The following criteria were considered for decision regarding delivery –

1. Absent diastole or reversal of diastolic flow.
2. Abnormal fetal heart tracing.
3. Worsening of maternal condition e.g. pre-eclampsia.
4. Gestational age > 32 weeks in the group with high resistance diastolic flow.
5. Severe fetal growth restriction with AFI < 5.

Steroids were administered as a single dose only once to all women between 28 and 34 weeks to enhance fetal lung maturity. Induction of labor was performed with prostaglandin E_2 gel or oxytocin if spontaneous labor did not start in those women planned for vaginal delivery. A group of women with associated obstetric indications were scheduled for elective cesarean section. The women in whom labor was induced and those who spontaneously went into labor were delivered by emergency cesarean section if fetal distress developed during labor.

Data collected included diagnosis to delivery interval, abnormal fetal heart pattern before labor, elective cesarean section rate, emergency cesarean section rate for fetal distress, gestational age at delivery, birth weight, apgar scores, admission to neonatal intensive care unit, and need for positive pressure ventilation. The neurological outcome was assessed at birth and the babies were followed up for 6 months in terms of delayed milestones, spasticity with cognitive functional delay, and any episode of seizures.

Results

Forty-four of the 134 (32.8%) pregnancies with low birth weight had abnormal doppler waveforms in the umbilical arteries. Doppler waveform of the umbilical artery was considered abnormal if S/D ratio was equal to or more than three or diastolic flow was absent / reversed in fetuses above the gestational age of 28 weeks [4-7]. The mean for the normal S/D ratio group (n=90) was 2.6 and for the higher S/D ratio group (n=30) 3.7 (Table 1). An additional 12 fetuses had absent end diastolic velocity and two fetuses had reversal of diastolic flow.

Small for gestational age babies with abnormal umbilical artery velocity waveforms had shorter diagnosis to delivery interval than those with normal doppler (Table 2). These fetuses with abnormal umbilical artery doppler waveforms are at an increased risk for oligohydramnios (Table 1) and for delivery at a lower gestational age. The total fetuses delivered at less than 36 weeks gestation were 16 (17.8%) in normal doppler group, 13 (43.3%) in low-end diastolic velocity group and 12 (85.7%) in the group with absent diastole / reversed end diastolic velocity (Table 2). Frequently the fetuses in the abnormal doppler group were delivered by cesarean section and mainly because of non-reassuring fetal heart pattern than the fetuses with normal umbilical flow findings (Table 3). These neonates had lower birth weight percentiles with higher perinatal asphyxia in terms of lower apgar score which was below 7 at birth. The need for positive pressure ventilation for resuscitation was more in fetuses with absent / reversed diastolic flow studies. The fetuses with normal diastolic flow and with low diastolic flow had comparable requirement for positive pressure ventilation.

Babies with abnormal umbilical artery doppler studies were more than twice as likely to be admitted to the neonatal

Table 1. Antenatal characteristics of study population (n=134).

	Normal doppler (n=90, 67.2%)	Abnormal doppler (n=44, 32.8%)	
		Low end diastolic flow (n=30, 23.1%)	Absent diastole / reversed end diastolic velocity (n=14, 9.7%)
Mean S/D ratio	2.6	3.7	——
Pregnancy induced hypertension /pre-eclampsia	26 (28.9%)	11 (36.7%)	100 (71.4%)
Gestational diabetes	03 (3.3%)	02 (6.7%)	03 (21.4%)
Oligohydramnios	16 (17.8%)	16 (53.3%)	09 (64.3%)
Severe anemia	02 (2.2%)	02 (6.7%)	Nil
Uterine anomaly	02 (2.2%)	02 (6.7%)	Nil

Table 2. Neonatal Outcome.

	Normal doppler (n=90, 67.2%)	Abnormal doppler (n=44, 32.80%)	
		Low end diastolic velocity (n=30; 23.1%)	Absent diastole/ reversed end diastolic velocity (n=14; 9.7%)
Delivery at less than 36 weeks gestation	16 (17.8%)	13 (43.3%)	12 (85.7%)
Diagnosis of abnormal doppler to delivery interval	NA	10.4 days	Within 6 hours
Nonreassuring nonstress test	05 (6.3%)	06 (20%)	9 (64.3%)
Average birth weight	2144 g	1938 g	1429 g
Neonatal inensive care unit admission	36 (40%)	21 (70%)	14 (100%)
Average stay in neonatal care unit (days)	2.3	5.5 (17.5)	
Need for positive pressure ventilation	9 (10%)	03 (10%)	08 (57.10%)
Apgar < 7 at birth	12 (13.3%)	03 (10%)	08 (57.1%)
Hypoglycemia	Nil	02 (6.7%)	02 (14.3%)
Abnormal neurological outcome at 6 months follow up	Nil	Nil	02 (14.3%)
Sex			
(a) Female	49	17	10
(b) Male	41	13	04

Table 3. Labor outcome in 134 women with IUGR babies.

	Normal doppler (n=90; 67.2%)	Abnormal doppler (n=44; 32.8%)	
		Low end diastolic velocity (n=30; 23.1%)	Absent diastole / reversed end diastolic velocity (n = 14; 9.7%)
Spontaneous labor	34 (37.8%)	03 (10%)	Nil
Induction of labor	19 (21.1%)	03 (10%)	01 (7.1%)
Emergency cesarean section for fetal distress	9 (10%)	06 (20%)	11(78.6%)
Elective cesarean section for other obstetric indications	28 (31.1%)	18 (60%)	02(14.3%)

Table 4 Maternal obstetrical history of study population (n=134).

	Normal doppler (n=90; 67.2%)	Abnormal doppler (n=44; 32.8%)
Maternal age (years)	26.7	27
Parity (a) Primipara	29 (32.2%)	17 (38.6%)
(b) Multipara	61 (67.8%)	27 (61.4%)
Past history of small for gestational age	04 (4.4%)	05 (11.4%)
Past history of pregnancy induced hypertention	06 (6.7%)	05 (11.4%)
Past history of perinatal death	08 (8.9%)	04 (9.1%)

intensive care unit and spend longer time there (Table 2). Overall 40% (n=36) of small for gestational age babies with normal umbilical artery doppler studies were admitted to neonatal intensive care unit (NICU) in contrast to 70% (n=21) small for gestational age babies with low-end diastolic velocity on umbilical artery doppler. However all the fetuses with absent / reversed diastolic umbilical artery flow were admitted to the neonatal intensive care unit (Table 2).

A small percentage of babies 9.1% (N=4) with abnormal umbilical artery doppler studies were found to have hypoglycemia after birth (Table 2). However, the birth weight, gestational age at delivery, and doppler status were not entered into a logistic regression model to actually signify the doppler status for hypoglycemia.

Maternal characteristics

There was no major difference in maternal age and parity between mothers with small for gestational age babies of normal umbilical artery velocimetry and those with abnormal umbilical artery velocimetry studies. The obstetric history suggested a higher incidence of small for gestational age babies and pregnancy induced hypertension in previous pregnancies of the mothers of the abnormal doppler group (Table 4).

There was a trend for more underlying medical problems in mothers with abnormal doppler studies. They had high incidence of pregnancy induced hypertension, diabetes mellitus and severe anemia developing during the pregnancy (Table 1). 36.7% (n=11) fetuses with low-end diastolic velocity and 71.4% (n=10) with absent / reversed diastolic flow were associated with maternal gestational hypertension. However, the mothers of small for gestational age babies with normal umbilical artery doppler studies also had a high incidence of 28.9% (n=26) pregnancy induced hypertension. Oligohydramnios was associated with pregnancy induced hypertension and was about three times more commonly seen with abnormal doppler studies.

Gestational diabetes was present in 6.7% (n=2) of the mothers with small for gestational age fetuses with low-end diastolic velocimetry compared to 21.4% (n=3) of the mothers with absent diastole / reversed end diastolic velocity. Only 3.3 % (n=3) of the mothers of small for gestational age fetuses with normal doppler studies had gestational diabetes. Women with uterine anomalies and severe anemia had three times higher incidence of abnormal doppler studies with small for gestational age fetuses (Table 1).

Mothers of small for gestational age babies with abnormal umbilical artery doppler studies were more likely to need cesarean section for fetal distress. These women were less likely to be induced than those with normal umbilical artery doppler studies (Table 3).

Discussion

Doppler velocimetry identifies normal and altered blood flow velocity in the umbilical artery and is responsive to changes in placental resistance. It is a noninvasive technic that evaluates abnormal fetal hemodynamics that results in abnormal pregnancy outcome. It has been shown by various workers [7-9] that perinatal morbidity and mortality were significantly greater in small for gestational age babies with abnormal umbilical artery doppler studies than in those with normal studies. Various studies have reported on the association of abnormal umbilical artery velocity waveforms with fetal growth restriction [1,2] and its prediction. All infants whose birth weight is below the 10th percentile are not exposed to a pathologic process in utero but some are constitutionally small and healthy. It is a challenge to differentiate the fetus with pathologic growth restriction and hence at risk for perinatal complications from constitutionally small but healthy fetus.

The pregnancies most likely to be benefitted from the use of umbilical artery velocimetry are those with the diagnosis of intrauterine growth retardation (IUGR) whether as an idiopathic process or in presence of gestational hypertension with or without gestational diabetes, severe anemia, and uterine anomalies (Table 1). Meta-analysis of the use of doppler ultrasonography in high-risk pregnancies with IUGR has revealed a statistically significant improved perinatal outcome [10]. The results shown in Table 2 reveal that fetuses with abnormal umbilical artery velocimetry have a shorter diagnosis of abnormal doppler to delivery interval, early delivery, decreased birth weight, increased NICU admissions and duration of stay there, and need for positive pressure ventilation with low apgar scores than those with normal doppler. Various workers have noticed in fetuses with abnormal umbilical artery doppler velocimetry a similar poor perinatal outcome [4,6,10-12]. There are old reports suggesting that doppler studies of velocity waveforms of the umbilical artery are more useful in identifying fetuses prone for IUGR than sonographic estimation of fetal weight [13,14]. However, the recent work of Vergani et al [15] finds that in fetal growth restricted cases delivered at or beyond 34 weeks gestation with abnormal umbilical artery velocimetry, it independently predicts the likelihood of admission to the NICU for reasons other than low birth weight alone.

Conversely, the study of McCowan et al [11] found that the effect of abnormal umbilical artery doppler was not important in terms of admission of the newborn to the nursery, birth weight, and gestational age. The hypoglycemia in neonates was found to be dependant on the birth weight and not on abnormal umbilical artery doppler findings.

Mothers of small for gestational age babies with abnormal doppler studies were more likely to have history of obstetric complications in the previous pregnancy as observed by McCown et al [11]. They had high incidence of delivering small for gestational age babies, gestational hypertension, and history of perinatal death in the previous pregnancy (Table 4). These mothers of small for gestational age babies with abnormal umbilical artery doppler velocimetry frequently delivered by cesarean section for fetal distress and were less likely to undergo induction of labor than those with normal doppler. There was a still higher incidence of cesarean section for fetal distress in the group with absent diastole / reversed diastolic flow with reduction of the induction (Table 3) with subsequent low apgar scores and greater need for positive pressure ventilation as was also noticed by Seyam et al [16] and Rochelson et al [7]. Baschat and Weiner [12] provide clear evidence to support that antenatal surveillance is unnecessary despite ultrasonography findings consistent with or diagnostic of IUGR if both umbilical artery S/D ratio and the amniotic fluid volume are normal. However, they noticed that commonly, complications occurred to those fetuses with abnormal doppler studies, which correlates with our study in terms of non-assuring fetal heart rate (Table 2). It is reasonable to assume that decreased uteroplacental perfusion during uterine contractions is likely to further jeopardize gaseous exchange in fetuses with preexisting abnormal umbilical artery velocimetry.

The incidence of neurological deficit was noticed at 6 months follow up in two of the 14 babies (14.3%) with severely abnormal umbilical artery velocimetry with absent diastole / reversed diastolic flow (Table 2). The incidence of neurological deficit among the babies of our study group is lower than that reported by Voalcamonico et al [17] who followed up the babies up to 2 years and detected an incidence of 36%. They also noticed a perinatal mortality of 26% in their study group compared to 6% in the control group. There was no case of necrotizing enterocolitis in any fetus with abnormal doppler. This finding is contrary to the evaluation of 77 growth-restricted neonates by Bhatt et al [18] who suggest a positive predictive value of 52.6% for necrotizing enterocolitis in the group with absent diastole / reverse diastolic flow. There was no perinatal mortality in our study.

Doppler velocimetry studies of umbilical artery can provide the obstetrician important information regarding fetal well-being to help him improve fetal outcome. Our data indicates that the umbilical artery velocimetry can distinguish the group of small for date fetuses in risk of complications. The application of nonstress test and biophysical scoring should guide the evaluation of such women for timing the delivery. Hecher et al [14] have pointed out the role of venous doppler studies in assessing the degree of hypoxemia and in guiding

the correct time for delivery. The fetuses with absent diastole / reversed diastolic flow on follow up have sequelae of neurological deficit in high proportions. Umbilical artery doppler study reflects disease severity in small for gestational age fetuses and is not independently associated with neonatal outcome. This impresses upon the clinician to shift his focus from small size of fetus, which may be clinically not important to fetoplacental function that is integral to neonatal outcome. Umbilical flow velocimetry studies should be an integral parameter while evaluating in-utero health of the growth restricted fetuses.

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