

Role of Fetal Arterial Doppler Study in the Decision Making of High-Risk Pregnancies

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ABSTRACT

Background: Doppler velocimetry has become an important tool in the evaluation and management of disorders like fetal growth restriction, pre-eclampsia, fetal anemia, and fetal hypoxia. The purpose of our study is to understand the impact of these complicated pregnancies on the changes in Doppler indices of umbilical and middle cerebral arteries of the fetus. Our study will also aim to analyze whether these changes can aid the timely recognition of fetal compromise.

Materials and Methods: We have conducted a prospective observational study over a period of six months from May 2015 to October 2015 in department of Obstetrics and Gynecology of a tertiary care hospital in Ahmedabad, India. 100 patients were enrolled according to the inclusion and exclusion criteria, and Doppler studies of the umbilical artery and the Middle cerebral artery were done. Follow up was taken and data assimilated regarding mode of delivery, 5-min Apgar score, fetal and perinatal deaths, neonatal complications or morbidity and admission to intensive care.

Results: Out of 38 patients with abnormal perinatal outcome 65.78% showed presence of umbilical artery PI value >95th percentile, and 34.22% showed PI value <95th percentile. 31.57% patients had either absent or reversed umbilical end diastolic flow. With reversed flow, 100% perinatal morbidity was observed with mortality in 75%. 25 patients (65.79%) showed MCA PI value ≤ 1 while 13 (34.21%) had PI ≥ 1 . Among patients with abnormal perinatal outcome 55.26% showed cerebro-placental ratio <1 compared to 8.06% in normal cases.

Conclusions: Doppler velocimetry complements the biophysical methods of fetal surveillance to determine more precisely the degree of fetal compromise and aids in deciding the appropriate timing of delivery of a compromised fetus. Low cerebroplacental ratio of <1 is an acute predictor of adverse perinatal outcome.

Keywords: Fetal growth restriction, pre-eclampsia, ultrasound, fetal monitoring, cerebroplacental ratio

advances such as “power” or “energy” Doppler make the diagnosis easier and more accurate. Research has been carried out on the Doppler patterns of almost all fetal vessels to study the subtle changes in blood flow in various high risk obstetric conditions.^{2,3} Color Doppler can be used as a tool for fetal surveillance in high risk pregnancies. The purpose of our study is to understand the association between complicated pregnancy conditions like pre-eclampsia, fetal growth restriction, diabetes mellitus and other maternal medical disorders, with the changes in Doppler indices of umbilical and middle cerebral arteries of the fetus. Our study will also aim to analyze whether these changes can aid the timely recognition of fetal compromise. The perinatal outcome can be improved by choosing the appropriate time and route of termination of pregnancy on the basis of the altered Doppler indices.

MATERIALS AND METHODS

We have conducted a prospective observational study over a period of six months from May 2015 to October 2015 in department of Obstetrics and Gynecology of a tertiary care hospital in Ahmedabad, India. 100 patients were enrolled for the study. The patients were selected from the outpatient department and from admission in antenatal ward. All the women had a singleton pregnancy of > 24 weeks gestation.

Inclusion criteria

- Preeclampsia (hypertension ≥ 140 mmHg systolic and ≥ 90 mmHg diastolic and proteinuria in a previously normotensive woman)
- Fetal growth restriction (weight below the 10th percentile for gestational age)
- Anemia (patients having severe anemia < 7g% detected at full-term)
- Gestational Diabetes Mellitus and other maternal medical disorders.

Exclusion criteria

- Patient with congenital anomaly of fetus, chronic Hypertension.
- Multiple gestation

INTRODUCTION

Since the application of Doppler ultrasonography for obstetric use was first made in 1970, many trials have been carried out to determine its diagnostic importance. It has proven to be a very efficient non-invasive technique for evaluation of fetomaternal hemodynamics. The fetomaternal circulation is dynamically changing in order to accommodate the increasing needs of the fetus. According to Callen's Ultrasonography in Obstetrics and Gynecology, “Abnormalities in one or more of these vascular systems occur prior to the clinical and laboratory appearance of, or as a result of, many pathological conditions of pregnancy”.¹ Any technique which can aid this diagnosis can play an important role in the clinical management of high risk pregnancies. Newer technological

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- Patients not delivered in our hospital
- Patients with unreliable LMP dates and maturity not confirmed by first trimester scan.

Pre-eclampsia was defined as hypertension (systolic pressure ≥ 140 mmHg and diastolic pressure ≥ 90 mmHg with proteinuria in a previously normotensive woman. FGR was diagnosed clinically and confirmed by ultrasound parameters with estimated fetal weight less than 10th percentile for the gestational age, according to reference values by Hadlock et al.⁴

The subjects enrolled for the study were followed up from the point of recruitment up to the time of delivery. Routine adequate antenatal care was given at each visit. All patients were evaluated first by grayscale ultrasound and then subjected to Doppler studies of the umbilical artery and the Middle cerebral artery. The pregnancies were followed up and data were collected regarding mode of delivery, gestational age at birth, birth weight, 5-min Apgar score, number of fetal and perinatal deaths, neonatal complications or morbidity and admission to NICU along with its duration.

Doppler study was considered abnormal when:

1. Umbilical artery pulsatility index (PI) more than 95 percentile of reference values by Acharya G et al⁵ or if the diastolic flow was absent or reversed.
2. Middle cerebral artery pulsatility index (PI) less than lower limit of reference values by Mari G et al.⁶
3. Cerebro-placental ratio less than 1 or less than 2 S.D. of reference values by Gramellini D et al.⁷

Perinatal outcome of baby was decided based on parameters like fetal demise, 5 min Apgar score, NICU admission or neonatal death before 30 days of life.

RESULTS

A total of 100 patients categorized under high risk pregnancy were enrolled for the study with gestational age between 24-42 weeks of pregnancy. Doppler study was carried out for them. The patients were followed till delivery and perinatal outcome was noted. All the data were recorded. 38 (38%) patients had abnormal perinatal outcome while 62 (62%) patients were noted to have satisfactory perinatal outcome.

Pregnancy complication	Present study	
	Number*	Percentage
Fetal growth restriction	60	60
Pre-eclampsia	46	46
Anemia	29	29
Medical disorders associated with pregnancy (cardiac, renal, diabetes, jaundice)	12	12
Bad Obstetric History (recurrent pregnancy loss, high risk factors associated in previous pregnancy – pre-eclampsia, diabetes, FGR, blood disorders, anemia, etc.)	28	28
* may be more than 100 in this table, as some of the patients had more than one pregnancy complication.		

Table-1: Distribution of cases in relation to pregnancy complications

Due to more frequent presence of more than one risk factor in a single patient, individualization of risk factor analysis by Doppler study and its outcome was not possible in the current study. Data analysis was done by presence or absence of abnormal Doppler indices during a particular gestational

Pulsatility Index	Perinatal outcome		Total
	Abnormal	Normal	
>95th percentile	25 (65.78%)	15 (24.19%)	40
<95th percentile	13 (34.22%)	47 (75.81%)	60
PI > 1	26 (68.42%)	11 (17.74%)	37
PI ≤ 1	12 (31.58%)	51 (82.26%)	63
End diastolic flow			
Absent or reversed flow	12 (31.57%)	0 (0%)	12
Forward flow	26 (68.42%)	62 (100%)	88

Table-2: Outcome in relation to Umbilical Doppler (with gestational age specific cut off values)

MCA PI Ratio	Abnormal perinatal Outcome	Normal perinatal outcome	Total
PI ≤ 1	25 (65.79%)	16 (25.81%)	41
PI > 1	13 (34.21%)	46 (74.19%)	59

Table-3: Outcome in relation to MCA PI value (with gestational age specific cut off values)

Cerebroplacental Ratio (CPR)	Perinatal Outcome		
	Abnormal perinatal Outcome	Normal perinatal outcome	Total
CPR < 1 (Abnormal)	21 (55.26%)	5 (8.06%)	26
CPR ≥ 1 (Normal)	17 (44.73%)	57 (91.93%)	74

Table-4: Outcome in relation to Cerebroplacental Ratio (CPR)

Mode of delivery	Present study (n=100)	
	Number	Percentage
Vaginal delivery		
Full term	29	29
Pre-term	27	27
Caesarean section		
Full term	25	25
Pre-term	19	19

Table-5: Distribution of cases according to mode of delivery

Perinatal outcome	Number	Percentage*
Still birth	5	13.1
Neonatal death	7	18.4
Intracranial hemorrhage	2	5.3
Neonatal hyperbilirubinemia	6	15.8
Early onset septicemia	4	10.5
5-min APGAR score <7	14	36.8
Admission to neonatal intensive care unit (NICU) >24 hrs.	33	86.8
Caesarean section for fetal distress	17	44.7
*may be more than 100 in this table, as some of the neonates had more than one morbidity		

Table-6: Abnormal perinatal outcome in the study population (n=38)

age, deviation from normal to abnormal Doppler finding in high risk patients, fetal outcome, and morbidity and mortality associated with the neonate.

DISCUSSION

Umbilical artery flow velocity waveforms correlate with hemodynamic changes in the fetoplacental circulation. Out of 38 patients with abnormal perinatal outcome, 68.42% showed presence of umbilical artery PI value > 1 , and 31.58% showed PI value < 1 . Out of 62 patients with normal perinatal outcome 17.74% had PI value > 1 and 82.26% had PI value < 1 . Out of 38 patients with abnormal perinatal outcome 65.78% showed presence of umbilical artery PI value > 95 th percentile, and 34.22% showed PI value < 95 th percentile. While among 62 patients with normal perinatal outcome 24.19% had PI value > 95 th percentile and 75.81% had PI value < 95 th percentile. Thus the present study shows that the umbilical artery Doppler is quite significant in detecting abnormal perinatal outcome. For the prediction of abnormal perinatal outcome using umbilical artery PI > 1 , the results of present study are comparable with those of Gramellini et al.⁷ Out of 38 patients with abnormal perinatal outcome, 31.57% had either absent or reversed UA end diastolic flow while among 62 patients with normal perinatal outcome all had forward flow. REDF indicates impending fetal demise in 48 hours.⁸ With reversal of diastolic flow in umbilical artery 100% abnormal perinatal outcome was observed. This corresponds to the study done by Wladimiroff et al.⁸ Also, the perinatal mortality observed in patients with absent or reversed UA end diastolic flow was 75%, as compared to studies by Madzali⁹ (40%), Bhatt¹⁰ (50%) and Lakhkar¹¹ (100%).

The centralization of circulation by redistribution of blood from the peripheral pool to the vital organs is an adaptive process which is necessary to keep the brain and heart from developing severe hypoxia. Thus increased flow in the MCA permits evaluation of fetal compromise and hypoxia. But according to Vyas et al¹², with the development of brain edema, this adaptation is reversed. When there is reversal of this adaptive process, there is a very poor outcome of these fetuses as shown by Konje et al.¹³ The increased diastolic flows start diminishing, progressing to high resistance flows, absent diastolic and then reverse diastolic flows, usually associated with abnormalities in the CTG tracing.¹⁴ In our study, out of 38 patients with abnormal perinatal outcome, 25 (65.79%) showed MCA PI value ≤ 1 . 16 cases (25.81%) among normal perinatal outcome had PI ≤ 1 .

The calculated MCA PI to UA PI ratio (the cerebroplacental ratio or CPR) is significant in detecting abnormal perinatal outcome in high risk fetuses. The umbilical-placental and cerebral vascular beds both undergo hemodynamic adjustments in FGR. CPR is a Doppler index that reflects both of these areas and hence can be useful in identifying fetuses with increased placental and/or decreased cerebral resistance.¹⁴ Among patients with abnormal perinatal outcome 55.26% showed presence of CPR < 1 compared to 8.06% in normal perinatal outcome.

In the present study, 56 patients (56%) underwent vaginal delivery out of which 29 delivered at full term (≥ 37 weeks of gestation) and 27 were preterm deliveries. 44 patients (44%)

underwent caesarean section, out of which 25 were full term deliveries and 19 were preterm.

There were 5 still births (5%). Among 7 babies (7%) who underwent neonatal death, 3 babies were delivered by Caesarean section for fetal distress with abnormal Doppler changes (MCA or CPR changes) and 4 were delivered vaginally. 2 expired after 1 day in NICU, 1 after 2 days, 2 after 4 days and remaining 2 survived for more than ten days in NICU. 88 babies (88%) survived.

38 patients had abnormal perinatal outcome in terms of still birth, neonatal death, sepsis, cerebral palsy, and hospitalization > 48 hours that required intubation.

CONCLUSION

Doppler velocimetry of the umbilical and middle cerebral arteries proved to be a practical and reasonably reliable procedure to predict the abnormal perinatal outcome. Doppler waveform studies correlate well with the pathophysiological events in utero-placental and fetoplacental insufficiency noted among patients with high risk pregnancies such as FGR, pre-eclampsia, diabetes, anemia etc. It helps us to predict, diagnose and intervene in circulatory disturbances such as redistribution of blood flow, hypoxia, cerebral edema, acidosis, cardiac decompensation and fetal death. Doppler velocimetry complements the biophysical methods of fetal surveillance to determine more precisely the degree of fetal compromise and aids in deciding the appropriate timing of delivery of a compromised fetus. Umbilical artery Doppler is highly sensitive in detection of FGR and placental insufficiency due to improper trophoblastic invasion of spiral arteries in pre-eclampsia while MCA Doppler is very useful in predicting small for gestational age babies with adverse perinatal outcome. Low cerebroplacental ratio (CPR) of < 1 is an acute predictor of adverse perinatal outcome. Thus, fetal arterial Doppler is an important tool for decision-making in high-risk pregnancies.

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