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Original Article

Color Doppler Imaging of Cerebral-Umbilical Pulsatility Ratio in Intrauterine Growth Retardation

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Abstract

Background: *Intrauterine growth retardation (IUGR) refers to a condition in which a fetus is unable to achieve its genetically determined potential size. IUGR may also be defined as growth at the 10th or less percentile for weight of the all fetuses at that gestational age. It has long been recognized that impaired fetoplacental perfusion is associated with intrauterine growth retardation. Ultrasonography with Color Doppler has provided a new tool for this purpose.* ***Objective***: *To evaluate the role of Color Doppler ultrasonography in the diagnosis of IUGR.* ***Materials and Methods***: *This prospective study was carried out in the department of Radiology & Imaging of Dhaka Medical College Hospital within a period of January 2010 to September 2011 on 90 patients aged between 17−35 years who were clinically suspected as cases of IUGR or previously USG diagnosed cases of IUGR.* ***Results***: *The highest incidence of IUGR was found in the age group between 21−25 years. The mean gestational age at birth was 33.2 ± 3.5 weeks and mean birth weight 1.3 ± 6.2 kg in case of abnormal cerebral-umbilical (C/U) ratio group. According to cerebral-umbilical pulsatility index (PI) value 65 cases (72.2%) were diagnosed as abnormal and 25 (27.8%) as normal flow pattern. Perinatal findings showed that 67 were small for gestational age (SGA) and 23 had normal birth weight. The validity of cerebral-umbilical PI ratio for diagnosis of IUGR was studied by calculating sensitivity, specificity, accuracy, PPV and NPV.* ***Conclusion***: *In this study Color Doppler findings of cerebral-umbilical vessels and the validity tests reveal that Color Doppler evaluation of middle cerebral artery (MCA) and umbilical artery (UA) PI ratio is an useful modality in diagnosis of IUGR.*

Key words: *Intrauterine growth retardation; Color Doppler; Sonography; Middle cerebral artery; Umbillical artery*

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Introduction

Impaired fetoplacental perfusion is associated with intrauterine growth retardation.[1] Pregnancy-related complications make a significant contribution to perinatal mortality and morbidity.[2,3] Intrauterine growth retardation (IUGR) is defined as estimated fetal weight at <10th percentile or abdominal circumference <5th percentile irrespective of estimated fetal weight.[1,4] Severe intrauterine growth retardation is defined as estimated fetal weight <5th percentile.[5]

Intrauterine growth retardation is a syndrome characterized by failure of the fetus to reach its

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normal growth potential.[6] It is the 2nd leading cause of perinatal death and it is associated with significant morbidity including increased rates of meconium aspiration, hypoglycemia, respiratory distress syndrome, intrapartum asphyxia, developmental delay and still birth.[1,7]

Intrauterine growth retardation is associated with an increased risk of perinatal mortality and morbidity and impaired neurodevelopment.[8,9] The correct detection of the compromised intrauterine growth retardation fetus to allow for timely intervention is a main objective of antenatal care.[10] Umbillical artery and middle cerebral artery doppler velocimetry is the most rigorous evaluation test among the noninvasive tests of fetal well being.[11]

Placental insufficiency, whether primary or secondary to maternal factors such as hypertension, poor nutrition etc, is the most common cause of intrauterine growth retardation which is an important obstetric problem on account of the high association perinatal mortality and morbidity.[1,2,12] It is essential to recognize placental insufficiency early so that its hazards can be reduced. Doppler ultrasound enables a better understanding of the hemodynamic changes and has therefore become one of the most important clinical tools for fetomaternal surveillance in high risk pregnancies.[13]

Doppler value was considered as normal when the cerebral-umbilical ratio was above 1.08 and below this the value was considered abnormal.[1,2,14] Cerebral-umbilical ratio remains constant in the last 10 weeks of pregnancy and therefore it is used (a single cut-off value of 1.08) for all the cases of 30−41 weeks of gestation.[15] In intrauterine growth retardation, umbilical blood flow is significantly reduced, mainly due to change in the placental vascular resistance.[16]

In pregnancy with chronic fetal hypoxia, the blood volume in the fetal circulation is redistributed in favor of vitally important organs, i.e., the heart, kidney and brain.[17] Vasodilatation of the middle cerebral artery with an increase in diastolic flow through it results in a decrease in its pulsatility index. The resulting hyperperfusion is considered pathological.[1,2,18]

The brain sparing effect is associated with an abnormal cerebral-umbilical ratio (<1.08).[19] However, if hypoxia persists, the diastolic flow returns to the normal level. The cerebral-umbilical ratio remains constant during the last 10 weeks of gestation and provides better diagnostic accuracy than either vessels' pulsatility index (PI) alone.[1,20] Doppler waveform abnormalities have been reported to be the most accurate predictor of poor neonatal outcome.[21]

A Color Doppler apparatus may be used to assess the blood flow velocity profiles in the umbilical arteries to determine if complications associated with impaired trophoblastic invasion of the placental bed could be predicted by this measurement.[22] On the basis of above facts "measurement of cerebral umbilical pulsatility ratio is a better predictor of small for gestational age fetuses".

Materials and Methods

This prospective study was done from January 2010 to September 2011 on 90 selected patients aged 17−35 years referred to the department of Radiology & Imaging.

Color Doppler scanning technique

All 90 patients were subjected to duplex Color Doppler examination, using 3.5 MHz transducer with 3 mm sample volume and medium filter. During the examination, the patient was in a semirecumbent position and the fetus was in quiet resting state. A Doppler beam was placed on the region of interest where the color flow was clearly noted and arterial pulsation was identified.

The flow velocity waveform was recorded from the umbilical artery (UA) and the fetal middle cerebral artery (MCA). After technically satisfactory Doppler waveform had been recorded, the PI of the umbilical artery and the MCA was noted and the ratio of the MCA and UA PI (the C/U ratio) was calculated.

Sonographic variable

Umbilical artery and middle cerebral artery PI

The formula of PI is (Peak systole−end diastole)/mean peak value. The cerebral-umbilical PI ratio remains constant in the last 10 weeks of the pregnancy and, therefore, a single cut-off value of 1.08 is considered normal. Below that value, velocimetry was considered abnormal.[1]

C/U ratio = MCA PI/UA PI; Normal: >1.08, Abnormal: <1.0

Results

All the subjects were divided into four age groups (Table I). The mean age of the subjects was 22.5 ± 9.8 years. The maximum 43.3% were within 21−25 year age group and minimum was within 16−20 year age group.

Table I: Age distribution of patients (n=90)

Age groups (years)	Number	Percentage
16−20	4	4.4
21−25	39	43.3
26−30	35	39
31−35	12	13.3
Total	90	100

Out of 90 patients who were evaluated by Doppler USG to identify the normal and abnormal cerebral umbilical pulsatility index ratio, 65 (72.2%) were found abnormal and 25 (27.8%) were normal (Table II). Out of 90 patients 67 (74.4%) had small for gestational age (SGA) and 23 (25.6%) had normal birth weight baby (Table III). Out of 90 patients 67 (74.4%) delivered at 34 ± 3.7 weeks and 23 (25.6%) delivered at 39 ± 1.6 weeks of gestational age (Table IV).

The Color Doppler diagnosis of IUGR was done on 90 patients who were referred to Radiology & Imaging Department from OPD or Indoor patient of DMCH. Perinatal follow-up was done and birth weight measurement taken on those patients and reports were collected. Validity of the tests were confirmed by calculating sensitivity, specificity, positive predictive value, negative predictive value and accuracy by using standard formulae (Table V and Table VI).

Table II: Distribution of normal and abnormal C/U PI ratio findings (n=90)

PI ratio	Number	Percentage
Normal (>1.08)	25	27.8
Abnormal (<1.08)	65	72.2
Total	90	100

Table III: Distribution of perinatal diagnosis of SGA determined by birth weight measurement (n=90)

Perinatal findings	Number	Percentage
SGA	67	74.4
Normal	23	25.6
Total	90	100

Table IV: Distribution of patients according to gestational age at delivery in weeks (n=90)

C/U PI ratio	Number	Gestational age at delivery in weeks (Mean ± SD)
Abnormal	67	34 ± 3.7
Normal	23	39 ± 1.6
Total	90	

Table V: Sensitivity, specificity, accuracy, positive predictive value and negative predictive value of the Color Doppler evaluation of cerebral-umbilical pulsatility ratio for diagnosis of SGA

Validity test	Percentage
Sensitivity	94
Specificity	91.3
Accuracy	93.4
Positive predictive value	97
Negative predictive value	84

Table VI: Color Doppler evaluation of cerebral-umbilical pulsatility ratio correlation with small for gestational age (n=90)

C/U pulsatility ratio	Small for gestational age determined by birth weight measurement		Total
	SGA present	SGA absent	
Abnormal pulsatility ratio (<1.08)	63 (True positive)	2 (False positive)	65
Normal Pulsatility ratio (>1.08)	4 (False negative)	21 (True negative)	25
Total	67	23	90

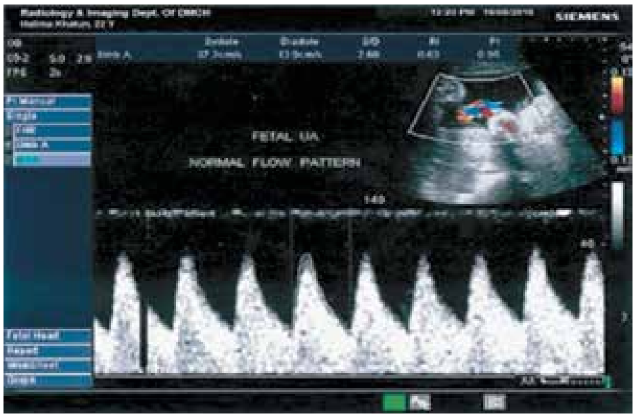

Fig 1. Color Doppler of the umbilical artery showing a normal UA waveform pattern with low impedence, high diastolic flow and decreased pulsatility index

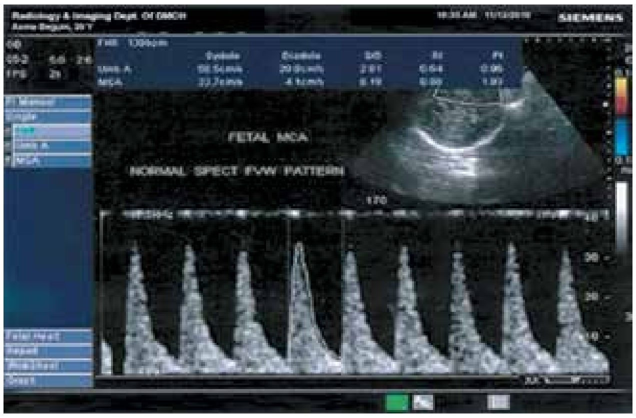

Fig 2. Color Doppler of the normal middle cerebral artery showing a normal MCA waveform pattern with high resistance, low diastolic flow and increased pulsatility index

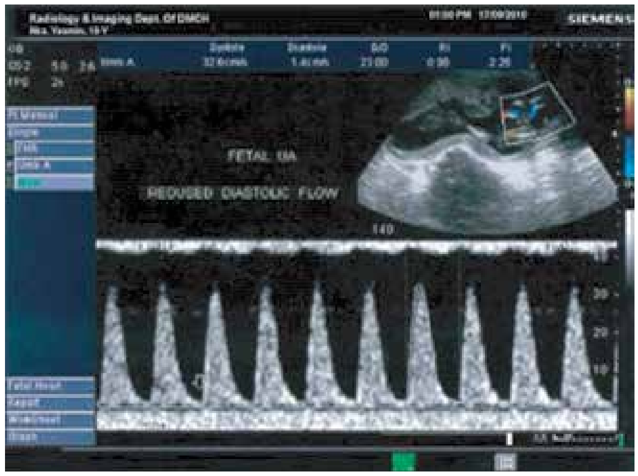

Fig 3. Abnormal umbilical artery waveform patterns showing markedly reduced diastolic flow

Fig 4. Abnormal middle cerebral artery waveform pattern showing low resistance and high diastolic flow due to cerebral vasodilatation

Discussion

IUGR is a pathological condition which is strongly related to the development and function of the uteroplacental and fetoplacental circulation. An adequate fetal circulation is necessary for fetal growth.

Umbilical artery (UA) velocimetry correlates with hemodynamic changes in the fetoplacental circulation. With an increase in the number of the tertiary stem villi and arterial channels as the fetoplacental compartment develops, the impedence in the UA decreases. A diastolic component in the UA flow velocity waveform appears during the early second trimester and progressively increases in the gestational age. A mature UA flow velocity waveform pattern shows low impedence and high diastolic flow with a low pulsatility index. During normal pregnancy, the MCA shows high resistance and low diastolic flow with an increase in the pulsatility index.

Cerebro-umbilical (C/U) ratio remains constant in the last 10 weeks of pregnancy and so in this study a single cut-off value of 1.08 is considered for all cases of 30–41 weeks of gestation. Using the cut-off value study population was divided into normal and abnormal groups.

In pregnancies with chronic fetal hypoxia, the blood volume in the fetal circulation is redistributed in favor of vitally important organs, e.g. heart, kidneys and brain. Vasodilatation of the MCA, with an increase in diastolic flow through it, results in a decrease in its PI. The resulting hyperperfusion is considered pathological.

The Color Doppler study of C/U vessels has made an advancement in new generation sonography equipment and expertise, which has brought a revolution in the field of diagnostic imaging to diagnose IUGR prenatally. This noninvasive imaging modality will be able to replace the other invasive diagnostic procedures.

This current study was carried out with an aim to establish the usefulness of C/U pulsatility index ratio in diagnosis of IUGR. Validity test was done by calculating sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV).

The present study findings were discussed and compared with previously published relevant studies. In this study, 90 patients were included. It was observed that maximum (43.3%) patients were within 21–25 years age group and minimum (4.4%) within 16–20 years age group.

In this study it was found that out of 90 patients 74.4% who had abnormal C/U ratio delivered at 34 ± 3.7 weeks and 25.6% with normal ratio delivered at 39 ± 1.6 weeks. One study[22] had shown that a C/U pulsatility ratio of less than 1.08 had a sensitivity of 68%, specificity 98.4%, positive predictive value 94.4%, negative predictive value 88.8% and diagnostic accuracy 90% for predicting adverse perinatal outcomes in IUGR. Another study[1] using C/U PI ratio of less than 1.08 found sensitivity of 83.3%, specificity 100%, positive predictive value 100%, negative predictive value 94.3% and diagnostic accuracy 95.6% for predicting adverse perinatal outcomes in IUGR.

In this study using a C/U pulsatility ratio of less than 1.08, sensitivity was 94%, specificity 91.3%, positive predictive value 97%, negative predictive value 84% and diagnostic accuracy 93.4% for predicting adverse perinatal outcomes in IUGR.

In asymmetrical IUGR there is high umbilical artery PI and low middle cerebral artery PI. As a result, the C/U ratio is lower than normal growth retarded fetuses.

Different studies[1,2,10,22] have observed in their series that Doppler was significantly correlated with adverse perinatal outcomes where sensitivity ranged from 83–90% and specificity from 71–100%. Thus the parameters provide strong evidence that Doppler analysis is of great value in evaluation of prenatal diagnosis of fetuses at risk in IUGR.

The cerebral-umbilical PI ratio incorporates data of both placental status (umbilical artery) and fetal response (middle cerebral artery) in the prediction of adverse outcomes.

In this study, comparing the use of the C/U pulsatility index ratio, we found similar efficiency in the prediction of IUGR and adverse perinatal outcomes. This implies that perinatal centers can use this method in the evaluation of cases of IUGR.

Finally, color Doppler findings of cerebral-umbilical vessels and the validity tests in this study are almost identical as observed by other investigators. So, it can be concluded that Color Doppler evaluation of MCA and UA pulsatility ratio is an useful modality for diagnosis of IUGR.

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