Correlation of abnormal umbilical artery Doppler Indices and mode of delivery in intrauterine growth restriction

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ABSTRACT

Background: Elevated impedance to blood flow in the placenta is reflected by abnormal umbilical artery (UA) indices as seen in intrauterine growth restriction (IUGR).

Aims: To correlate abnormal UA Doppler velocimetry parameters with birth weight and mode of delivery in IUGR.

Material and Methods: A prospective study was conducted in Department of Obstetrics and Gynaecology, Kamla Nehru State Hospital for Mother and Child, IGMC Shimla HP, over a period of one year from August 2017 to July 2018. The study included a total of 120 consecutive clinically suspected cases of singleton IUGR pregnancies, at 34–40 weeks of gestation. Umbilical artery (UA) Doppler indices including systolic/diastolic (S/D) ratio, pulsatility index (PI), and resistive index (RI) were measured. The decision regarding mode delivery was based on absent or reversal of diastolic flow, abnormal fetal heart tracing, and other maternal and fetal conditions, e.g., preeclampsia or abnormal biophysical profile. The birth weight, mode of delivery, and the reasons for emergency cesarean section were noted. Statistical analysis was performed using Statistical Package for Social Sciences, version 16.0 and a P value <0.05 was considered statistically significant.

Results: Abnormal UA PI (>1.42) was seen in 24 fetuses. Among these, 69% (n = 16) underwent a cesarean delivery, and 91% (n = 22) had a birth weight less than 2.5 kg. Statistically significant association was noted with abnormal UA PI (P-value: <0.01), abnormal UA RI (P-value: <0.001), and abnormal UA S/D (P-value: <0.001) and cesarean delivery. The main indication for cesarean section was fetal distress.

Conclusion: Abnormal UA Doppler indices are significantly associated with cesarean deliveries and low birth weight babies.

Key words: Cesarean section; intrauterine growth restriction; low birth weight; umbilical artery Doppler indices.

Introduction

Color Doppler is a noninvasive tool offering direct information on vascular resistance and blood flow to the fetus. In pregnancies complicated by intrauterine growth restriction (IUGR), there is elevated impedance to blood flow in the placenta reflected by abnormal umbilical artery (UA) velocimetry findings.

IUGR is a complex fetal growth disorder where the estimated fetal weight is less than the 10th percentile for the corresponding gestational age.[1] The causes of IUGR are varied, relating mainly to placental insufficiency. This makes the characterization and management of IUGR challenging.[2,3] With the placenta unable to keep up with the growing demands of oxygen and nutrition, IUGR fetuses exhibit a high risk of severe morbidity, the need...
for induction of labor, and cesarean delivery. It has been also linked with impaired intellectual performance, hypertension, and obesity in adulthood.\textsuperscript{(4)} Etiologically, IUGR is responsible for 50\% of perinatal deaths occurring in preterm babies and for 20\% in term births.

Globally, it is estimated that IUGR affects 24\% of the new born, accounting for 30 million infants annually. Approximately, 75\% of all infants in the Asian continent are IUGR.\textsuperscript{(5)} In India, the National Neonatal Perinatal database reports the incidence of IUGR to be 9.65\% among hospital born live infants, while a recent UNICEF survey reports the incidence to be about 25–30\%.\textsuperscript{(5)}

Thus, the present study was designed to evaluate UA Doppler indices in clinically suspected cases of IUGR.

Aims and objective
To evaluate the UA Doppler velocimetry parameters and to correlate these with any adverse perinatal outcomes.

Material and Methods

Study design
This was a prospective, observational study, conducted in Department of Obstetrics and Gynecology, Kamla Nehru State Hospital for Mother and Child (KNSH), IGMC, Shimla, in association with the Department of Radiology, IGMC, Shimla, HP over a period of 1 year from August, 2017 to July, 2018.

Sample size
A total of 120 consecutive clinically suspected cases of IUGR with singleton pregnancies at 34–40 weeks of gestation attending the KNSH OPD were included in the study after taking an informed consent.

Inclusion criteria
1. Gestational age between 34 and 40 weeks
2. Singleton pregnancies
3. All of the above antenatal women willing to participate.

Exclusion criteria
1. Multiple pregnancies
2. Congenital abnormalities in the fetus.

Method of study
The antenatal women consenting for participation were followed up from the day of clinical diagnosis of IUGR till the pregnancy outcome. Complete evaluation of the patients was done with gestational age determination, relevant investigations, and Doppler study. The clinical diagnosis of IUGR was made on the basis of poor maternal weight gain and a noncorrespondence of fundal height with the period of gestation. In clinically suspected cases of IUGR, Umbilical Doppler waveform study was performed by GE LOGIQ P6 scanner with 3.5 MHz transducer. The guidelines prescribed by the PreNatal Diagnostic Techniques (PNDT) act, 1994 were strictly followed. The Doppler examination of the patient was done in recumbent position. The UA velocity waveforms were obtained during periods of fetal inactivity and apnoea. The readings were taken at the midpoint of in the free-floating loop of the cord. The Doppler indices measured were systolic/diastolic (S/D) ratio, pulsatility index (PI), and resistive index (RI). The reference values of UA PI > 1.42, UA RI > 0.72, UA S/D ratio > 3 were taken as an indicator of IUGR.\textsuperscript{(6,7)}

The criteria considered for decision regarding mode delivery were absent diastolic or reversal of diastolic flow, abnormal fetal heart tracing, and other maternal and fetal conditions, e.g., preeclampsia, abnormal biophysical profile, and severe fetal growth restriction with AFI less than five. The mode of delivery and the reasons for emergency cesarean section were recorded.

Statistical analysis
Data management and statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 16.0.\textsuperscript{(8)} A level of statistical significance (\(P\)-value) of less than 0.05 was considered significant.

Results
The study group comprised of 120 consecutive singleton pregnancies with clinical suspicion of IUGR. The mean gestational age at the first Doppler velocimetry examination was 35.2 weeks ± 3.46 weeks. Acceptable waveforms were obtained from all study subjects with repeat Doppler in five cases. A total of three babies born with congenital malformations were excluded from the study. The mean age of the subjects was 21.8 years ± 3.1 SD. The youngest was 18 years, whereas the oldest was 35 years old. Majority of the subjects (70\%; \(n = 83\)) were from the rural background.

Out of the 117 subjects, 51 (44\%) were primi gravidae. Among the 66 multi gravidae, 45 (38\%) were second gravidae, 14 (12\%) third gravidae, and seven were fourth gravidae or more. The BMI ranged from 14.2 kg/m\(^2\) to 25.5 kg/m\(^2\) with the average BMI being 19.93 kg/m\(^2\). The average height of the subjects was 153.72 cm ± 4.07 SD and the average weight at the first antenatal visit was 47.17 kg ± 5.82 SD.

The associated risk factors are shown in Table 1. The commonest being oligohydramnios (\(n = 21\); 18\%) while in 24\% (\(n = 28\)) patients, multiple complicating antepartum
risk factors were observed. In the significant past obstetric history, 15% (n = 10) had suffered the previous stillbirth and in 7% (n = 5), two or more spontaneous abortions were noted.  

The mean birth weight was 1.92 kg. The minimum birth weight was 900 grams and a single neonate with birth weight of 3 kg was born. Out of the 39 term live births and 78 late preterms, low birth weight was noted in 26 and 61 neonates, respectively.

**Doppler velocimetry parameters**

The correlation of UA Doppler indices with birth weight is shown in Table 2. Abnormal UA PI (>1.42) in utero was seen in 24 fetuses, and in these 91% (n = 22) had a birth weight less than 2.5 kg. Abnormal UA RI (>0.72) was noted in 22 fetuses and among these 90% (n = 20) neonates, the birth weight was less than 2.5 kg. Abnormal UA S/D ratio was observed in 37 fetuses with 92% (n = 34) neonates with a low birth weight. Out of the 37 cases with abnormal UA S/D ratio, there were four cases with absent end-diastolic flow. In these, three had a low birth weight and one was a fresh stillbirth. The UA S/D ratio was statistically significant (P-value = 0.03).

Statistically significant association was noted with abnormal UA PI P-value < 0.01, abnormal UA RI < 0.001, and abnormal UA S/D < 0.001, and cesarean delivery. Out of 117 births, it was observed that 24 subjects who had an abnormal UA PI (>1.42), 69% (n = 16) underwent a cesarean delivery. In a total of 53 cesarean deliveries, the major indication of cesarean sections was fetal distress with non-reassuring fetal heart rate 49% (n = 26) and meconium stained liquor in 11% (n = 6). Other indications included failed induction 17% (n = 9) and poor Manning score (BPP<6/10) in 15% (n = 8) of the cases.

The sensitivity, specificity, PPV, and diagnostic accuracy of UA PI was 84.45%, 70%, 82%, and 71.79%, respectively, for prediction of IUGR.

**Discussion**

The main pathology in fetal growth restriction is uteroplacental insufficiency which may either be primary or secondary due to any maternal disorder, fetal chromosomal anomalies, or fetal infections. Maternal causes of placental insufficiency include hypertension, collagen vascular disease, renal disease, poor nutrition, and drug or alcohol abuse. Viral infections like cytomegalovirus and toxoplasmosis, and fetal chromosomal anomalies like triploidies and trisomies 13 and 18 may contribute to the causation of IUGR. [4]

IUGR has been divided into two subtypes. Symmetric IUGR occurs due to early onset of an insult, such as a chromosomal anomaly or an infection. Asymmetric IUGR is usually late in onset resulting in a small fetal abdomen, due to decreased glycogen stores in the liver, whereas the head and extremities are normal or near-normal in size. This is seen more commonly in primary or secondary placental insufficiency.

Doppler imaging is a reliable diagnostic tool for detection of IUGR and is based on the rationale that abnormalities in placental circulation cause increased resistance to blood flow leading to growth retardation. This increased resistance further causes decreased velocity in the feeding arteries. This disproportionate slowing of diastolic flow relative to systolic flow leads to elevation of a number of Doppler indices, including the systolic/diastolic ratio and the pulsatility index. Thus, Doppler indices provide a unique, noninvasive, and safe method of studying blood flow characteristics in both the fetoplacental and uteroplacental circulation. Hence, it is being extensively used in clinical evaluation of high-risk pregnancies.

The present study comprised of women aged between 18 and 35 years old with the maximum number (42%) of subjects in the range of 21–25 years. The mean age was 21.8 years as is generally observed in the Indian context and comparable to the study conducted by several authors. [9,10]

The percentage of the subjects who were underweight (BMI <18.5) in the present study was 23%. This was comparable to the study conducted by Vishwekar et al. (2016) [11] and Gandhi and Mehta (2015) [12] where 20% and 26% were
underweight, respectively. The mean BMI in the present study was 19.93 kg/m² comparable to 22.1 kg/m² noted by Parra-Saavedra et al. (2013). However, the present study found this relation to be statistically not significant (P-value = 0.75). This may be explained by a limited sample size of the present study.

The present study reported 17.9% subjects with oligohydramnios, 16.2% had pregnancy-induced hypertension, 2.5% with gestational diabetes mellitus, and 0.8% were with heart disease. Pregnancy-induced hypertension was seen to be associated with IUGR in 42% of the cases by Geetha and Prasad (2016), 50% by Sharma and Chandani (2016), and 48% of the cases by Vishwekar et al. (2016) in comparison to 16.2% in the present study. The differences may be due to the use of a gray-scale ultrasound to diagnose IUGR. The percentage of pregnancy-induced hypertension noted in our study was comparable to 14.4% observed by Dhand et al. (2011) and 20% observed by Bora et al. (2015) where IUGR was suspected on the basis of clinical diagnosis. Pregnancy-induced hypertension leading to uteroplacental insufficiency is a major etiological factor responsible for IUGR. It can either be an indicator of the severity of pregnancy-induced hypertension or due to chronic hypoxia as a result of the disease process.

The associated risk factors are shown in Table 1. Oligohydramnios was associated with IUGR in 17.9% of the cases in the present study which was comparable to Vishwekar et al. (2016), Geetha and Prasad (2011), and Sharma and Chandani (2016) who report oligohydramnios in 20%, 24%, and 25%, respectively, suggestive of the hypoxic status of the fetus in IUGR pregnancies. Malik and Saxena (2013) reported that the sensitivity of oligohydramnios for detecting IUGR was only 21.1%, which was statistically not significant.

Our study reports 17.9% (n = 21) subjects with bad obstetric history. The association of bad obstetric history in IUGR as reported by different authors is variable: 2.5% and 36% respectively, suggestive of the hypoxic status of the fetus in IUGR pregnancies. Malik and Saxena (2013) reported that the sensitivity of oligohydramnios for detecting IUGR was only 21.1%, which was statistically not significant.

There were 70% neonates who had a low birth weight, 19% with a normal birth weight, 10% with very low birth weight, and 4% with extremely low birth weight in our study. Several authors report low birth weight neonates to be around 48% and 48.3%. There were 78 preterm births in the present study which may contribute to the higher percentage of low birth weight neonates seen in the present study. Further, Sparks et al. (2011) report that diagnosis on clinical assessment, as is utilized in the present study, to be less than 35% sensitive in assessing IUGR. This explains the 19% average birth weight neonates seen in the present study where clinical assessment was used to diagnose IUGR. The correlation of UA Doppler indices and birth weight are shown in Table 2.

The mode of delivery is depicted in Table 3. The present study noted 59% cesarean deliveries and 41% vaginal deliveries among IUGR fetuses with abnormal Doppler indices. In the present study, out of 15 cases with an abnormal UA PI, 80% had a cesarean delivery and 75% had an adverse perinatal outcome. This finding was comparable to the statistically significant relation noted by Singh et al. (2013) with 61.5% cesarean deliveries in their study. However, Malik and Saxena do not note a significant relation.

In the present study, there were 49% cesarean deliveries performed for fetal distress, 17% for failed induction, 15% for poor biophysical profile (BPP < 6/10), and 11% for meconium-stained liquor. This was comparable to the 46% cesareans for fetal distress noted by Geetha and Prasad (2016), Parra-Saavedra et al. (2016) had 27% of the cesareans performed for fetal distress speculating that IUGR fetus owing to their decreased placental reserve are considerably less tolerant to oxygen deprivation during labor.

The present study reports a sensitivity of 89.4%, specificity of 70%, PPV of 82%, and diagnostic accuracy of 71.7%. The UA directly reflecting the changes in the blood flow within the placenta is considered to be more specific than a sensitive criterion. This higher specificity of 81.1% was noted by Geetha and Prasad (2015), Sharma and Chandani (2016) and Vishwekar et al. (2016) also noted a higher specificity being 97.5% and 84.6%, respectively. Khanduri et al. (2012) observed a specificity of 75.9%, while in the present study it was 70%. This difference may be due to inclusion of such cases in the present study which were clinically assessed to be IUGR but found not to be so. The diagnostic accuracy of UA PI, as shown in Table 4, in the present study was 71.7%, which was comparable to 75% in Khanduri et al. (2012) and 71% by Geetha and Prasad (2015).

### Table 3: Umbilical Artery Doppler Indices and mode of delivery

| Mode of delivery | Umbilical Artery Doppler Indices | S/D |
|------------------|---------------------------------|-----|
|                  | ≤1.42                           | >1.42 |
|                  | ≤0.72                           | >0.72 |
|                  | <3                              | ≥3   |
| Vaginal           | 56 (60%)                        | 8 (31%) |
|                  | 59 (62%)                        | 5 (20%) |
|                  | 54 (67%)                        | 10 (28%) |
| LSCS             | 37 (40%)                        | 16 (69%) |
|                  | 36 (38%)                        | 17 (80%) |
|                  | 27 (33%)                        | 26 (72%) |
| Total            | 93 (100%)                       | 24 (100%) |
|                  | 95 (100%)                       | 22 (100%) |
|                  | 81 (100%)                       | 36 (100%) |

PUA PI=0.135, not significant; UA RI=0.191, not significant; UA S/D ratio=0.03, significant
Conclusion

The present study found that there was statistically significant role of abnormal UA Doppler indices in prediction of low birth weight and increased incidence of cesarean for fetal distress. Keeping this in mind, a critical evaluation of an antenatal patients’ Doppler parameter offers a noninvasive and a comprehensive tool to assess the fetal well-being in utero.

However, a conclusive view regarding the implications of Doppler in IUGR can only be offered after extensive longitudinal evaluation of all Doppler parameters taking into account the variation in severity of IUGR and the gestational age at which it is diagnosed.

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Conflicts of interest
There are no conflicts of interest.

References

1. Vayssière C, Sentilhes L, Ego A, Bernard C, Cambourieu D, Flament C, et al. Fetal growth restriction and intra-uterine growth restriction: Guidelines for clinical practice from the French College of Gynaecologists and Obstetricians. Eur J Obstet Gynecol Reprod Biol 2015;193:10-8.
2. Faraci M, Renda E, Monte S, Di Prima FA, Valenti O, De Domenico R, et al. Fetal growth restriction: Current perspectives. J Prenat Med 2011;5:31-3.
3. Kurjak A, Fran A, Chervenak A. Donald School Textbook of Ultrasound in Obstetrics & Gynecology. 3rd ed. Jaypee Brothers Medical Publishers Ltd; 2011. ISBN 978-93-5025-259-8.
4. Ismail H, Chang YL. Sequelae of fetal growth restriction. J Med Ultrasound 2012;20:191-200.
5. United Nations Childrens Fund and World Health Organization. Low Birth Weight: Country, Regional and Global Estimates. New York, USA; 2004. UNICEF, ISBN-92-806-3832-7.
6. Arduini D, Rizzo G. Normal values of pulsatility index from fetal vessels: A rosssectional study on 1556 healthy fetuses. J Perinat Med 1990;18:165-72.
7. Kurmanavicius J, Florio I, Wisser J, Heibisch G, Zimmermann R, Müller R, et al. Reference resistance indices of the umbilical, fetal middle cerebral and uterine arteries at 24–42 weeks of gestation. Ultrasound Obstet Gynecol 1997;10:112-20.
8. SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc.
9. Malik R, Saxena A. Role of Colour Doppler indices in the diagnosis of intrauterine growth retardation in high-risk pregnancies. J Obstet Gynaecol India 2012;63:37-44.
10. Geetha M, Prasad KJ. Role of Colour Doppler in IUGR. J Dent Med Sci 2016;15:14-7.
11. Vishwekar PS, Rani SG, Jadhav A. Doppler ultrasound cerebroplacental ratio (CPR) - A better predictor of foetal outcome in clinically suspected IUGR pregnancies. J Evolution Med Dent Sci 2015;4:27-30.
12. Parra-Saavedra M, Crovetto F, Triunfo S, Savchev S, Parra G, Sanz M, et al. Added value of umbilical vein flow as a predictor of perinatal outcome in term small-for-gestational-age fetuses. Ultrasound Obstet Gynecol 2013;42:189-95.
13. Sharma DD, Chandani CK. Clinical study of IUGR cases and correlation of Doppler parameters with perinatal outcome. Int J Reprod Contracept Obstet Gynecol 2016;5:4290-6.
14. Dhand H, Kansal HK, Dave A. Middle cerebral artery Doppler indices better predictor for fetal outcome in IUGR. J Obstet Gynaecol India 2011;61:166-71.
15. Bora MK. Role of colour and spectral Doppler in the diagnosis of intra uterine growth retardation (IUGR) and its prediction of adverse perinatal outcome. Indian J Neonat Med Res 2015;3:17-22.
16. Sparks TN, Cheng YW, McLaughlin B, Esakoff TF, Caughey AB. Fundal height: A useful screening tool for fetal growth? J Matern Fetal Neonatal Med 2011;24:708-12.
17. Singh S, Verma U, Shrivastava K, Khanduri S, Goel N, Zaraa F, et al. Role of Color Doppler in the diagnosis of intra uterine growth restriction (IUGR). Int J Reprod Contracept Obstet Gynecol 2013;2:566-72.
18. Khanduri K, Chhabra S, Yadav S, Sabharwal T, Chaudhary M, Usmani T, et al. Role of Color Doppler flowmetry in prediction of intrauterine growth retardation in high-risk pregnancy. Cureus 2017;9:e1827.