The Professional Medical Journal
www.theprofesional.com

DOI: 10.29309/TPMJ/2020.27.3.4309

ORIGINAL PROF-0-4309

DIAGNOSTIC ACCURACY OF COLOR DOPPLER OF CEREBRAL AND UMBILICAL PULSATALITY IN DIAGNOSING IUGR, TAKING BIRTH WEIGHT AS GOLD STANDARD.

Syed Anjum Mehdi[1], Hassan Bukhari[2], Iqbal Hussain Dogar[3], Hira Bukhari[4]

1. DMRD, FCPS
Associate Professor Radiology
Allied Hospital, Faisalabad Medical University, Faisalabad.
2. FCPS, DEBR
Assistant Professor Radiology
Allied Hospital, Faisalabad Medical University, Faisalabad.
3. DMRD, FCPS
Associate Professor Radiology
Children Hospital, Lahore.
4. MBBS
Medical Officer
Sargodha Medical College, Sargodha.

Correspondence Address:
Dr. Syed Anjum Mehdi
Associate Professor Radiology
Allied Hospital, Faisalabad Medical University, Faisalabad.
dranjumehdi@gmail.com

Article received on:
26/03/2019
Accepted for publication:
15/12/2019

ABSTRACT… Objectives: To determine the diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard. **Study Design:** Descriptive, Cross Sectional Study. **Setting:** Department of Radiology, DHQ Hospital, Faisalabad. **Period:** 30th May 2016 to 29th November 2016. **Material & Methods:** Total 129 clinically suspected IUGR, 18 to 40 years of age with singleton pregnancy were included. Patients having Hb< 8.5 g/dl, chromosomal abnormality, chronic infections, severe systemic illness like uncontrolled diabetes mellitus, cardiac disease, renal or hepatic disease were excluded. Colour Doppler Ultrasonography of the cerebral and umbilical artery was performed in every patient and looked for IUGR. Colour Doppler sonography findings were compared with birth weight of baby. **Results:** Mean age was 30.26 ± 4.67 years. The mean gestational age was 38.60 ± 1.27 weeks. Mean parity was 2.68 ± 0.74. In Colour Doppler Ultrasonography positive patients, 64 were true positive while 09 were false positive. Among, 56 Colour Doppler Ultrasonography negative patients, 07 were false negative while 49 were true negative. Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard was 90.14%, 84.49%, 87.67%, 87.50% and 87.60% respectively. **Conclusion:** This study concluded that diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR is quite high.

Key words: Doppler Ultrasound, IUGR, Uterine Artery.

Article Citation: Mehdi S, Bukhari H, Dogar IH, Bukhari H. Diagnostic accuracy of Color Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard. Professional Med J 2020; 27(3):651-659.
DOI: 10.29309/TPMJ/2020.27.3.4309

INTRODUCTION

Intrauterine growth restriction is demarcated as a birth weight less than 10th percentile for a given gestational age. Fetus having birth weight less than 10th centile for gestational age are said to be Small for gestational age (SGA) infants.[1] Another way of explaining SGA is when the sonographic measurements of the fetal abdominal circumference are below an arbitrary percentile usually between the 2.5th and 10th on the representative chart.[2] Size criteria is not solely important, so some people include Doppler study of umbilical artery (showing abnormal spectral pattern) in the diagnosis of fetal growth restriction.

The etiology of IUGR is multifactorial.[3] Symmetrical IUGR is caused by congenital infections and chromosomal abnormalities, whereas asymmetrical IUGR is caused by utero-placental abnormality[4], maternal malnutrition and multiple pregnancies.[4] Its incidence is shown to be 65.0% in a study by Singh S et al.[5] IUGR is associated with large number of complications responsible for significant catatony, in the form of hyaline membrane disease, hypoglycemia, early onset sepsis, intra-partum asphyxia, meconium aspiration syndrome and stillbirth in extreme cases.[6] American College of Obstetricians and Gynecologists, emphasizes that IUGR is "one the most common and complex problems in modern obstetrics".[7]

Inspite of much advances in perinatal medicine, raised blood pressure remains one of the most important cause of fetal growth restriction, and the death rate among these fetuses remains

higher than in normal pregnancies. As fetal growth restriction is linked with increased death rate so in order to reduce mortality it is essential to detect the reduced fetal growth antenataly, so that proper intervention could be planned to increase the fetal survival rate.[8] Blood flow to the fetus and maternal blood flow can be assessed using non-invasive means such as doppler ultrasound and is and excellent replacement of various invasive means.[9]

Fetal size can be best assessed using the gold standard Ultrasonography. The application of Doppler Sonography is excellent in diagnosing various fetal abnormalities and associated factors, intrauterine growth restriction, hypertension, fetal hypoxia and cardiac malformations.[10]

24 hours before biophysical profile score decline Doppler decline is observed. Fetal intrauterine growth restriction can best managed by the aid of combined monitoring of multiple vessel (Uterine artery, Umblical artery, Middle cerebral artery and Ductus venosus)[11]

Fetal venous circulation (Ductus venosus) can be best assessed using Doppler sonography and plays an important role in monitoring growth restriction in order to maximize the efficiency at the time of delivery. Cerebral/umbilical ratio found to be the best parameter to diagnose small for gestational age fetus and also for diagnosing hostile upshots during pregnancy.[12] Hypoxic events which happen before labour is much more important than what happens during and after labour.[13] In a study, the sensitivity and specificity of colour Doppler cerebral/umbilical pulsatality in diagnosing IUGR was found to be 70.8% and 65.7% respectively.[5] In another study, it was found to be 80.0% and 45.0% respectively.[14] Similarly Bano S et al[15] in his study has shown this sensitivity and specificity of 44.4% & 100.0% correspondingly.

Since there is a controversy in the previous literature, so we had planned to carry out this study to define the diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard. And if it's diagnostic accuracy will be found high, then based on these results, some practical recommendations could be made in our routine practice guidelines for early detection of IUGR in this high risk group and subsequent adequate preventive measures could be taken in order to decrease the death rate in perinatal period as well as the catatonia of both fetus and mother.

MATERIAL & METHODS

Inclusion Criteria

- All patients with clinically suspected IUGR (as per-operational definition).
- Gestational age 32-41 weeks (assessed on LMP).
- Patients with singleton pregnancy (assessed on ultrasonography) and upto para-4.
- Patients 18-40 years of age.

Exclusion Criteria

- Patients having Hb< 8.5 g/dl, chromosomal abnormality, chronic infections (assessed on history and medical record).
- Patients with severe systemic illness like uncontrolled diabetes mellitus, cardiac disease, renal or hepatic disease (assessed on history and medical record).

Data Collection Procedure

Total 101 patients were included in this study. The patients were taken from Radiology department of DHQ/Allied Hospital, Faisalabad fulfilling the inclusion/exclusion criteria were selected after getting permission from ethical review committee. After taking informed consent and relevant history, colour Doppler Ultrasonography of the cerebral and umbilical artery was performed in every patient by using a high-resolution unit with a linear array probe centered at 7.5 MHz. All sonographic examinations were performed by senior consultant radiologist and experienced members of teaching staff in the presence of researcher and was looked for IUGR as per-operational definition. Colour Doppler sonography findings were compared with birth weight of baby which was delivered in the concerning gynecology ward. All this data was recorded on a specially

designed proforma (Annexure-I).

Statistical Analysis

All the data gathered was scrutinized through computer software SPSS 20.0. Standard deviation and Mean were calculated for measurable variables i.e. gestational age, height, age, weight, BMI and parity. Frequency and percentage were calculated for qualitative variables i.e. pregnancy induced hypertension (yes/no), h/o previous IUGR (yes/no), socioeconomic status (poor/middle/upper) and IUGR on colour Doppler sonography and birth weight. Positive predictive value, negative predictive value, Sensitivity, specificity and diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR was calculated using 2×2 contingency table and taking birth weight as gold standard.

Effect modifiers like age, gestational age, BMI, parity, pregnancy induced hypertension (yes/no), h/o previous IUGR (yes/no) and socioeconomic status (poor/middle/upper) were organized by stratification. Post-stratification likelihood ratio test was applied to see their effect on diagnostic accuracy and p-value ≤0.05 was considered substantial.

RESULTS

Patients included in this study were having age range from 18-40 years with mean age of 30.26 ± 4.67 years. Most of the patients 73 (56.59%), as shown in Table-I were falling in the range of 18 to 30 years.

The mean gestational age was 38.60 ± 1.27 weeks (Figure-1). Mean parity was 2.68 ± 0.74 (Table-II). Mean height was 150.34 ± 12.54 cm. Mean weight was 68.81 ± 7.59 kg. Mean BMI was 30.50 ± 2.11 kg/m2 (Table-III). Distribution of patients according to pregnancy induced hypertension, h/o previous IUGR and socioeconomic status is shown in Table-IV, V & VI respectively.

It was compulsory for all the patients to undergo Colour Doppler Ultrasonography of cerebral and umbilical arteries. Colour Doppler Ultrasonography showed the IUGR in 73 (56.59%) patients. Birth confirmed IUGR in 71 (55.04%) cases where as 58 (44.96%) patients' revealed no IUGR. In Colour Doppler Ultrasonography positive patients, 64 were true positive while 09 were false positive. Amid, 56 Colour Doppler Ultrasonography 07 were false negative and 49 were true negative as revealed in Table-VII. Overall negative predictive value, positive predictive value, sensitivity, specificity & diagnostic accuracy of Colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard was 90.14%, 84.49%, 87.67%, 87.50% and 87.60% respectively.

Categorization of diagnostic accuracy according to age group is revealed in Table-VIII & IX. Gestational age categorical arrangement is shown in Table-X & XI. Categorization of patients according to parity is shown in Table-XII and XIII. Table-XIV & XV have shown the categorization of diagnostic accuracy according to BMI. Categorization of diagnostic accuracy with respect to PIH is shown in Table-XVI & XVII. H/o previous IUGR categorization is revealed in Table-XVIII & XIX. Categorization of patients according to socioeconomic status is revealed in Table-XX, XXI and XXII.

Age (years)	No. of Patients	%Age
18-30	73	56.59
31-40	56	43.41
Total	129	100.0

Table-I. Distribution of patients according to Age. Mean ± SD = 30.26 ± 4.67 years

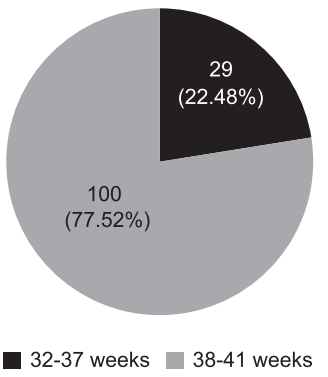


Figure-1. Distribution of patients according to gestational age (n=129).

Parity	Frequency	%Age
1-2	52	40.31
3-4	77	59.69

Table-II. Distribution of patients according to parity (n=154). Mean ± SD = 38.60 ± 1.27 weeks

BMI (kg/m²)	Frequency	%Age
≤30	76	58.91
>30	53	41.09

Table-III. Distribution of patients according to BMI (n=129). Mean ± SD = 2.68 ± 0.74

Pregnancy induced hypertension	Frequency	%Age
Yes	43	33.33
No	86	66.67

Table-IV. Distribution of patients according to pregnancy induced hypertension (n=129). Mean ± SD = 30.50 ± 2.11 kg/m²

H/o previous IUGR	Frequency	%Age
Yes	34	26.36
No	95	73.64

Table-V. Distribution of patients according to h/o previous IUGR (n=129).

Socioeconomic Status	Frequency	%Age
Poor	33	25.58
Middle	62	48.06
Upper	34	26.36

Table-VI. Distribution of patients according to socioeconomic status (n=129).

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	64 (TP)*	09 (FP)***	0.0001
Negative result on colour Doppler	07 (FN)**	49 (TN)****	

Table-VII. Diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard.

Sensitivity: 90.14%, **Specificity:** 84.49%,
Positive Predictive Value (PPV): 87.67%
Negative Predictive Value (NPV): 87.50%
Diagnostic Accuracy: 87.60%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	29 (TP)	05 (FP)	0.001
Negative result on colour Doppler	04 (FN)	35 (TN)	

Table-VIII. Stratification of age 18-30 years (n=73).

Sensitivity: 87.88%, **Specificity:** 87.50%
Positive Predictive Value (PPV): 85.29%
Negative Predictive Value (NPV): 89.74%
Diagnostic Accuracy: 87.67%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	35 (TP)	04 (FP)	0.001
Negative result on colour Doppler	03 (FN)	14 (TN)	

Table-IX. Stratification of age 31-40 years (n=56).

Sensitivity: 92.11%, **Specificity:** 77.78%
Positive Predictive Value (PPV): 89.74%
Negative Predictive Value (NPV): 82.35%
Diagnostic Accuracy: 87.50%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	17 (TP)	03 (FP)	0.001
Negative result on colour Doppler	01 (FN)	08 (TN)	

Table-X. Stratification of gestational age 32-37 weeks (n=29).

Sensitivity: 94.44%, **Specificity:** 72.73%
Positive Predictive Value (PPV): 85.0%
Negative Predictive Value (NPV): 88.89%
Diagnostic Accuracy: 86.21%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	47 (TP)	06 (FP)	0.001
Negative result on colour Doppler	06 (FN)	41 (TN)	

Table-XI. Stratification of gestational age 38-41 weeks (n=100).

Sensitivity: 88.68%, **Specificity:** 87.23%
Positive Predictive Value (PPV): 88.68%
Negative Predictive Value (NPV): 87.23%
Diagnostic Accuracy: 88.0%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	26 (TP)	04 (FP)	0.001
Negative result on colour Doppler	03 (FN)	19 (TN)	

Table-XII. Stratification of parity 1-2 (n=52).

Sensitivity: 89.66%, **Specificity:** 82.61%
Positive Predictive Value (PPV): 86.67%
Negative Predictive Value (NPV): 86.36%
Diagnostic Accuracy: 86.54%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	38 (TP)	05 (FP)	0.001
Negative result on colour Doppler	04 (FN)	30 (TN)	

Table-XIII. Stratification of parity 3-4 (n=77).

Sensitivity: 90.48%, **Specificity:** 85.71%
Positive Predictive Value (PPV): 88.37%
Negative Predictive Value (NPV): 88.24%
Diagnostic Accuracy: 88.31%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	39 (TP)	07 (FP)	0.001
Negative result on colour Doppler	04 (FN)	26 (TN)	

Table-XIV. Stratification of BMI ≤30 kg/m² (n=76).

Sensitivity: 90.70%, **Specificity:** 78.79%
Positive Predictive Value (PPV): 84.78%
Negative Predictive Value (NPV): 86.67%
Diagnostic Accuracy: 85.53%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	25 (TP)	02 (FP)	0.001
Negative result on colour Doppler	03 (FN)	23 (TN)	

Table-XV. Stratification of BMI >30 kg/m² (n=53).

Sensitivity: 89.29%, **Specificity:** 92.0%
Positive Predictive Value (PPV): 92.59%
Negative Predictive Value (NPV): 88.46%
Diagnostic Accuracy: 90.57%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	25 (TP)	01 (FP)	0.001
Negative result on colour Doppler	01 (FN)	16 (TN)	

Table-XVI. Stratification of presence of pregnancy induced hypertension (n=43).

Sensitivity: 96.15%, **Specificity:** 94.12%
Positive Predictive Value (PPV): 96.15%
Negative Predictive Value (NPV): 94.12%
Diagnostic Accuracy: 95.35%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	39 (TP)	08 (FP)	0.001
Negative result on colour Doppler	06 (FN)	33 (TN)	

Table-XII. Stratification of absence of pregnancy induced hypertension (n=86).

Sensitivity: 86.67%, **Specificity:** 80.49%
Positive Predictive Value (PPV): 82.98%
Negative Predictive Value (NPV): 84.62%
Diagnostic Accuracy: 83.72%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	18 (TP)	02 (FP)	0.001
Negative result on colour Doppler	01 (FN)	13 (TN)	

Table-XIII. Stratification of presence of h/o previous IUGR (n=34).

Sensitivity: 94.74%, **Specificity:** 86.67%
Positive Predictive Value (PPV): 90.0%
Negative Predictive Value (NPV): 92.86%
Diagnostic Accuracy: 91.18%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	46 (TP)	07 (FP)	0.001
Negative result on colour Doppler	06 (FN)	36 (TN)	

Table-XIV. Stratification of absence of h/o previous IUGR (n=95).

Sensitivity: 88.46%, **Specificity:** 83.72%
Positive Predictive Value (PPV): 86.79%
Negative Predictive Value (NPV): 85.71%
Diagnostic Accuracy: 86.32%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	18 (TP)	03 (FP)	0.001
Negative result on colour Doppler	01 (FN)	11 (TN)	

Table-XX. Stratification of poor socioeconomic status (n=33).

Sensitivity: 94.74%, **Specificity:** 78.57%
Positive Predictive Value (PPV): 85.71%
Negative Predictive Value (NPV): 91.67%
Diagnostic Accuracy: 87.88%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	30 (TP)	05 (FP)	**0.001**
Negative result on colour Doppler	03 (FN)	24 (TN)	

Table-XXI. Stratification of middle socioeconomic status (n=62).

Sensitivity: 90.91%, **Specificity:** 82.76%
Positive Predictive Value (PPV): 85.71%
Negative Predictive Value (NPV): 88.89%
Diagnostic Accuracy: 87.10%

	Positive Result on Birth	Negative Result on Birth	P-Value
Positive result on colour Doppler	16 (TP)	01 (FP)	**0.001**
Negative result on colour Doppler	03 (FN)	14 (TN)	

Table-XXII. Stratification of upper socioeconomic status (n=34).

Sensitivity: 84.21%, **Specificity:** 93.33%
Positive Predictive Value (PPV): 94.12%
Negative Predictive Value (NPV): 82.35%
Diagnostic Accuracy: 88.24%

DISCUSSION

In uterus fetal developmental restriction is owed by many causative agents that are directly or indirectly responsible for Placental insufficiency, including maternal factors such as raised blood pressure, poor nutrition, etc. IUGR is an important obstetrical problem owing to its associated high perinatal death rate and significant morbidity. This major cause of IUGR (placental insufficiency) needs early diagnosis and prompt treatment in order to reduce its hazardous complications. Color Doppler sonography owns important role in diagnosing fetomaternal hemodynamic disturbances, so are used frequently to diagnose placental insufficiency in high-risk pregnancies so as to decrease fetomaternal mortality and morbidity rate.[16] this study was conducted by me to diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard.

Indiviuals with 18-40 years age range and with mean age of 30.26 ± 4.67 years were taken. Most of the patients 73 (56.59%) were between 18 to 30 years of age. The mean gestational age was 38.60 ± 1.27 weeks. All the patients were supposed to undergo colour Doppler Ultrasonography of the cerebral and umbilical arteries. Colour Doppler Ultrasonography showed the IUGR in 73 (56.59%) patients. Birth confirmed IUGR in 71 (55.04%) cases where as 58 (44.96%) patients' revealed no IUGR. In Colour Doppler Ultrasonography of positive ones, 09 were false positive & 64 were true positive. Among, 56 Colour Doppler Ultrasonography negative ones, 49 were true negative and 07 were false negative. Overall positive predictive value, negative predictive value, sensitivity, specificity and diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard was 90.14%, 84.49%, 87.67%, 87.50% and 87.60% respectively. In a study specificity and sensitivity of colour Doppler cerebral/umbilical pulsatality in diagnosing IUGR was found to be 70.8% and 65.7% respectively.[5] In another study, it was found to be 80.0% and 45.0% respectively.[14] Similarly Bano S et al[15] in his study has revealed this sensitivity and specificity of 44.4% and 100.0% correspondingly.

According to another study, Dhand et al[17] the specificity and sensitivity of 61.5% and 44 %, was reported, in forecast of the IUGR product. The positive and negative prognostic values in their study were in 83 and 20 %, respectively. According to the current again low negative predictive value and high positive predictive value and specificity were obtained. The IUGR diagnosed cases on grayscale were included in the study and were the causative agent of low negative predictive value and thus responsible for increased pervasiveness. Negative predictive value is destined to decrease in a higher pervasiveness scenerio.[18] Narula et al[19] who stated sensitivity of 94 % for collective indices of the UA however significantly decreased sensitivity of 53.3% and specificity of 87.9 % is reported by Mulders et al[20] at around 32–34 weeks of pregnancy.

Patients after 30 weeks of gestation suffering from intrauterine growth restriction and severe pre-eclampsia are at an increased risk of developing fatal outcomes of the pregnancies and this was report with a sensitivity of 44.4%, specificity of 81.8%, NPV of 47.3% and PPV of 80%, by Lakhkar et al.[8] The author stated that the Umblical artery resistive index had a sensitivity of 58%, specificity of 71.7 %, positive predictive value of 35%, and NPV of 86.8%, thus demonstrating diagnostic accuracy of 56.8% for a catastrophic results in high risk IUGR cases and a sensitivity, specificity, PPV, and NPV of 44.4, 81.8, 80, and 47.3%, respectively, for trivial fatal results.[21] Resistive index of umblical artery was gauged for detection of pregnancy related adverse effects by Aali et al[22] in a study and he found that a cut-off value of 0.64, it was 100% sensitive, but only 44% specific; however, at a increased cut-off of 0.81, it was 28% sensitive only and 100% specific.

For forecasting fatal perinatal results it was concluded in one study[23] that a C/U pulsatality ratio of less than 1.08 had a specificity 98.4%, sensitivity of 68%, negative predictive value 88.8%, positive predictive value 94.4%, and diagnostic accuracy of 90%. One more study[24] using C/U PI ratio of less than 1.08 established

specificity 100%, sensitivity of 83.3%, negative predictive value 94.3%, positive predictive value 100%, and diagnostic accuracy 95.6% for forecasting fatal perinatal products in Intrauterine growth restriction. North et al[25] (1994) reported a sensitivity of 47% and a specificity of 91% for prediction of FGR.

Gramellini D, Folli MC, et al[26] clinched that small for gestational age newborns and other fatal perinatal outcomes can be better predicted b using cerebral umbilical Doppler ratio rather than using the umbilical artery or middle cerebral artery alone. In actual fact, in forecasting small for gestational age new borns, cerebral-umbilical ratio demonstrates high diagnostic accuracy of 70 % in comparison to the diagnostic accuracy of 65.5% for the umbilical artery and 54.4% for the middle cerebral artery. The fallouts were more cheering for forecasting of fatal perinatal products; diagnostic accuracy for the cerebral-umbilical ratio was 90%, equated with 78.8% for the MCA and 83.3% for the umbilical artery.

CONCLUSION

This study concluded that diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR is quite high. So, we recommend that there should be colour Doppler of cerebral and umbilical pulsatality of this high risk group for early detection of IUGR in order to take subsequent adequate preventive measures for decreasing perinatal death and disease rates of both fetus and mother.

REFERENCES

1. Anshul D, Neelu S, Suneeta G. **Significance of umbilical artery doppler velocimetry in the perinatal outcome of the growth restricted fetuses.** J Obstet Gynecol Ind. 2010; 60(1):38-43.

2. Grivell RM, Wong L, Bhatia V. **Regimens of fetal surveillance for impared fetal growth.** Cochrane Database Syst Rev. 2012; 6: CD007113.

3. Carberry AE, Gordon A, Bond DM, Hyett J, Raynes-Greenow CH, Jeffery HE. **Customised versus population-based growth charts as a screening tool for detecting small for gestational age infants in low-risk pregnant women.** Cochrane Data Sys Rev. 2014; 5: CD008549.

4. Unterscheider J, Daly S, Geary MP, Kennelly MM, McAuliffe FM, O'Donoghue K, et al. **Optimizing the definition of intrauterine growth restriction: The multicenter prospective PORTO Study.** Am J Obstet Gynecol. 2013; 208(4):290 e1-6.

5. Singh S, Verma U, Shrivastava K, Khanduri S, Goel N, Zahra 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.

6. Malhotra N, Chanana C, Kumar S, Roy K, Sharma JB. **Comparison of perinatal outcome of growth restricted fetuses with normal and abnormal umbilical artery Doppler waveforms.** Indian J Med Sci. 2006; 60(8):311-7.

7. **American college of obstetricians and gynecologists. Intrauterine growth restriction; ACOG practice bulletin no.** 12. Washington, DC: ACOG; 2000.

8. Grivell RM, Wong L, Bhatia V. **Regimens of fetal surveillance for impaired fetal growth.** Cochrane Database Syst Rev. 2012; 6:CD007113.

9. Affirevic Z, Stampalija T, Gyte GM. **Fetal and umbilical Doppler ultrasound in high risk pregnancies.** Cochrane Database Syst Rev. 2010; CD007529.

10. Rajesh M, Agamya S. **Role of colour doppler indices in the diagnosis of intrauterine growth retardation in high-risk pregnancies.** J Obstet Gynecol India. 2013; 63(1):37–44.

11. Kaponis A, Harada T, Makrydimas G, Kiyama T, Arata K, Adonakis,G et al. **The importance of venous doppler velocimetry for evaluation of intrauterine growth restriction.** J Ultrasound Med. 2011; 30:529-45.

12. Arathi AP, Jyothi HR, Ashwini AP. **A clinical study of role of colour doppler imaging in pregnancies at risk.** Intl J Biomed Res. 2013; 4(9):477-80.

13. Bora MK, Sharma K, Venkatesh BP, Shivanna U, Jayagurunathan U, Jagan VK. **Role of colour and spectral doppler in the diagnosis of intra uterine growth restriction (IUGR) and its prediction of adverse perinatal outcome.** Indian J Neonat Med Res. 2015; 3(1):17-22.

14. Ulkumen BA, Pala HG, Eskicioglu F, Baytur Y. **The analysis of doppler flow alterations in intrauterine growth restricted pregnancies.** Med Sci Dis. 2014; 1(3):80-4.

15. Bano S, Chaudhary V, Pande S, Mehta VL, Sharma AK. **Color doppler evaluation of cerebral-umbilical pulsatility ratio and its usefulness in the diagnosis of intrauterine growth retardation and prediction of adverse perinatal outcome.** Indian J Radiol Imaging. 2010; 20(1):20–5.

16. Fleischer A, Schulman H, Farmakides G, Bracero L, Blattner P, Randolph G. **Umbilical artery flow velocity waveforms and intrauterine growth retardation.** Am J Obstet Gynecol. 1985; 151:502–5.

17. Dhand H, Kansal HK, Dave A. **Middle cerebral artery doppler indices better predictor for fetal outcome in IUGR.** J Obstet Gynecol India. 2011; 61:166–71.

18. Mathai A, Parikh S, Chandra Sekhar G, et al. **Understanding and using sensitivity, specificity and predictive values.** Indian J Ophthalmol. 2008; 56(1):45–50.

19. Narula H, Kapila AK, Mohi MK. **Cerebral and umbilical arterial blood flow velocity in normal and growth retarded pregnancy.** J Obstet Gynecol India. 2009; 59(1):47–52.

20. Mulders LG, Wijn PF, Jongsma HW, et al. **A comparative study of three indices of umbilical blood flow in relation to prediction of growth retardation.** J Perinat Med. 1987; 15(1):3–12.

21. Lakhkar BN, Rajagopal KV, Gourisankar PT. **Doppler prediction of adverse perinatal outcome in PIH and IUGR.** Indian J Radiol Imaging. 2006; 16(1):10–16. doi: 10.4103/0971-3026.29064. [Cross Ref]

22. Aali BS, Narooi S, Mojtabaean B, et al. **Screening utility of umbilical artery Doppler indices in patients with preeclampsia.** Iran J Reprod Med. 2010; 8(4):167–172.

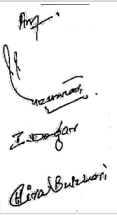
23. Rochelson B, Schulman H, Farmakides G, Bracero L, Ducey J, Fleischer A et al. **The significance of absent end-diastolic velocity in umbilical artery velocity waveforms.** Am J Obstet Gynecol 1987; 156:1213–1218.

24. Gramellini D, Folli MC, Raboni S, Vadora E, Merialdi A. **Cerebral umbilical Doppler ratio as a predictor of adverse perinatal outcome. Cerebral and umbilical ratio.** Obstet Gynecol 1992; 79: 416–420.

25. North RA, Ferrier CL long D, Townend K, Kincaid-smith F. **Uterine artery Doppler flow velocity waveforms in the second trimester for the prediction of pre-eclampsia and fetal growth retardation.** Obstet Gynecol 1994; 83:378-86.

26. Gramellini D, Folli MC, Raboni S, Vadora E, Merialdi A. **Cerebral-umbilical Doppler ratio as a predictor of adverse perinatal outcome.** Obstet Gynecol. 1992; 79:416-420.

AUTHORSHIP AND CONTRIBUTION DECLARATION

Sr. #	Author(s) Full Name	Contribution to the paper	Author(s) Signature
1	Syed Anjum Mehdi	Equal contribution of all authors.	
2	Hassan Bukhari		
3	Iqbal Hussain Dogar		
4	Hira Bukhari		