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Original Article

Radiology Section

Role of Colour and Spectral Doppler in the Diagnosis of Intra Uterine Growth Restriction (IUGR) and its Prediction of Adverse Perinatal Outcome

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ABSTRACT

Introduction and Aim: The aim of this study was to evaluate the diagnostic accuracy of the pulsatility index (PI) and resistive index (RI) in umbilical artery (UA) and middle cerebral artery (MCA) in the diagnosis of IUGR and its role in averting or minimising adverse perinatal outcome.

Materials and Methods: A total of 100 cases of clinically suspected IUGR were enrolled in to the study. The patient usually had an adverse factor in the current or previous pregnancy which was a contributing factor for developing Intra Uterine Growth Restriction (IUGR). All such cases underwent colour and spectral Doppler between 28 to 30 weeks in serial intervals and till delivery. Standardized cut off values were taken from previous studies for the data analysis. Diagnostic accuracy of Doppler indices for prediction of IUGR was done by assessing the newborn parameters for growth restriction and perinatal outcome.

Results: For UA PI overall diagnostic accuracy was higher at 70% and UA RI at 54%. For MCA overall diagnostic accuracy of PI was 76.6% and for RI, it was marginally low at 70.3%. In both the vessels the PI was having higher sensitivity and specificity from an early gestational age (GA). Further the sensitivity and specificity increased for both vessels with advancing GA.

Conclusion: We conclude that colour and spectral Doppler is an effective and non invasive tool which can predict and detect the cases of IUGR early in gestation and help in timely management thereby producing a favourable perinatal outcome.

Keywords: Doppler, IUGR, PI, Perinatal outcome, RI

INTRODUCTION

The term IUGR is used when the fetal weight is less than the 10th percentile for the GA or at least 2 standard deviation below the mean weight for their GA [1]. Its Incidence is about about 10% and is seen quite common in the practise of obstetrics. Accurate dating early in pregnancy is essential for a diagnosis of IUGR. Ultrasonography (USG) biometry is the gold standard for assessment of fetal size. Commonest cause of IUGR is utero-placental insufficiency and spectral Doppler is the only non invasive way to assess the same.

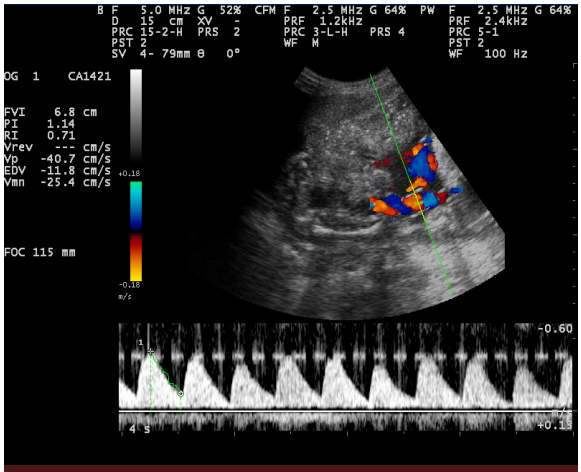
Both clinical and USG biometric measurements diagnose IUGR usually at a stage when the fetus is already compromised, unlike colour and spectral Doppler studies which can detect IUGR at an early stage. This is because color and spectral Doppler measures haemodynamic changes reflecting abnormalities in blood flow and resistance. Our study measures the PI and RI of the MCA and PI and RI of the UA in predicting IUGR. Timely diagnosis and management of IUGR is vital as with early detection and appropriate management, perinatal morbidity and mortality can be substantially reduced [2,3].

MATERIALS AND METHODS

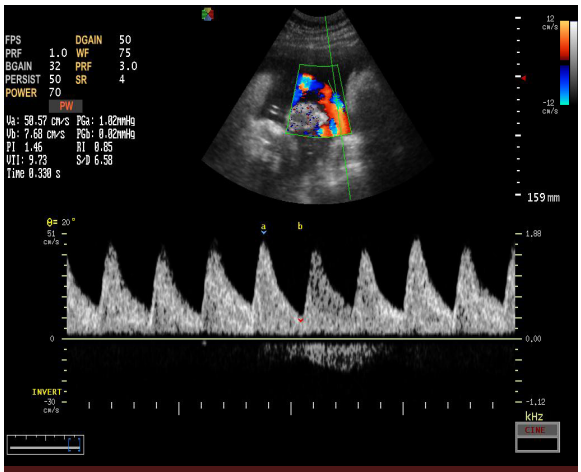
This was a prospective and observational study conducted in the Department of Radiodiagnosis in association with the Department of Obstetrics and Gynaecology and the Department of Paediatrics in Aarupadai Veedu Medical College and Hospital, Puducherry, India.

This two years study was done from June 2012 to June 2014. Hundred patients were enrolled in to the study referred from the Department of Obstetrics and Gynaecology with clinical diagnosis of IUGR.

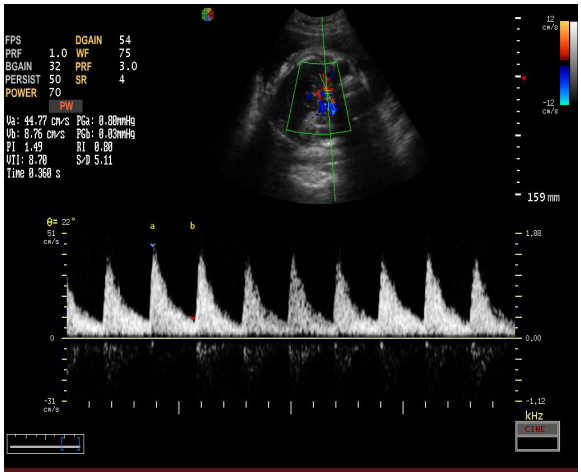
These were high-risk pregnancies having single fetus between 28 and 42 weeks of GA. Cases with fetal chromosomal abnormalities or major structural



[Table/Fig-1]: Colour Doppler image showing normal spectral tracing of umbilical artery



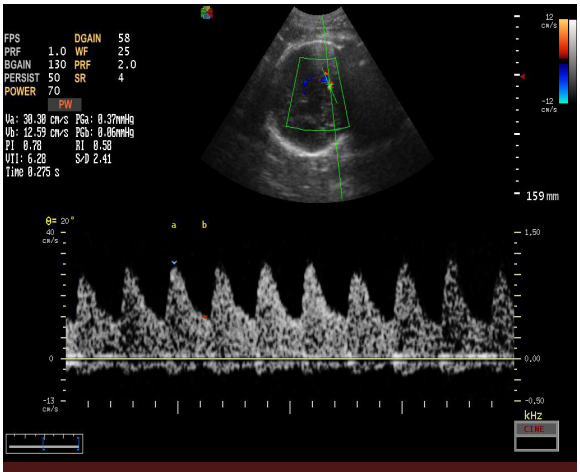
[Table/Fig-2]: Colour Doppler image showing abnormal spectral tracing of umbilical artery with increased PI and RI



[Table/Fig-3]: Colour Doppler image showing normal spectral tracing of fetal middle cerebral artery

malformations were excluded from the study. All the referred cases had associated adverse factors in the current or previous pregnancies, like anemia,systemic hypertension, cardiac disease, renal disease and pregnancy induced hypertension etc., to name a few.

GA determination was done based on last menstrual period and/or earliest available USG biometric data. A



[Table/Fig-4]: Image showing abnormal spectral tracing of fetal middle cerebral artery with decreased PI and RI

detailed history and examination was done following which, color and spectral Doppler was carried out from 28 to 30 weeks, at periodic intervals till delivery. The equipments used were Esoate MyLab 40 with multifrequncy (3.5 Mhz to 5 Mhz) curvilinear probe and Volusion S6 4D Colour Doppler machine from GE with multifrequncy (3.5 Mhz to 5.5 Mhz) curvilinear probe.

All patients underwent routine USG biometry for fetal GA determination following which Doppler study was done. All recordings were preferably obtained when there was no fetal breathing movements and with fetal heart rate between 120 and 140 beats per minute. For optimal results, angle between the ultrasound beam and the direction of blood flow was kept less than 60°. Doppler velocimetry was performed on the UA and the MCA close to the transducer and their RI and PI were recorded. In this study,the following reference values were used to standardize the technique.

Risk factors	No.of Cases	Percentage
Essential hypertension	5	5%
Heart disease	2	2%
Diabetes	4	4%
Anemia	27	27
Primary infertility	20	20
PIH	20	20
Previous IUGR	10	10
Breech	5	5
Recurrent abortion	5	5
Previous stillbirth	2	2

[Table/Fig-5]: Table showing risk factors, number of cases and its percentage n= 100

S.no.	IUGR	No. of Cases	Percentage
1.	Positive	72	72%
2.	Negative	28	28%

[Table/Fig-6]: Patient distribution with respect to clinically positive cases of IUGR n=100

For UA, PI value greater than 1.42 was taken as a positive predictor of IUGR and a value equal to or less than 1.42 was taken as normal, Arduini and Rizzo [4]. For UA, an RI value more than 0.72 was taken as positive predictor for IUGR and a value equal to or less than 0.72 was taken as normal, Kurmanavicius et al., [5] [Table/Fig-1, 2]. For MCA, a PI value of less than 1.5 was considered as a positive predictor of IUGR, Arduini and Rizzo [4]. A value equal to or more than 1.5 was considered to be normal.

For MCA, RI value of less than 0.59 was taken as an indicator of IUGR and a value equal to or greater than 0.59 was considered to be normal, Bahlmann F et al., [6] [Table/Fig-3, 4]. Systematic analysis of the findings at clinical examination, obstetric color and spectral Doppler waveforms and perinatal outcome was done. Perinatal outcome was evaluated based on baby's weight (in electronic weighing machine : LAICA sensitive (SS) to 10g weight difference), baby's length measured by infantometer, Ponderal index (Index of <2 indicate growth restriction) and Apgar score at 5 minutes. Minor adverse outcomes included caesarean delivery for fetal distress, APGAR score below 7 at 5 minutes, admission to neonatal intensive care unit (NICU) for treatment. Major adverse outcome criteria included perinatal deaths. Standard protocols were followed by the Department of Obstetrics and Gynaecology and Paediatrics in management of patients.

S. no	Cases	Caes-arean	Caesarean percentage	VD	VD percentage
1.	IUGR (72)	50	71%	22	29%
2.	No IUGR (28)	8	28%	20	72%

[Table/Fig-7]: Mode of delivery: n=100

RESULTS

Hundred patients were enrolled in the study with clinical suspicion of IUGR or with an adverse factor in previous or current pregnancy associated with IUGR [Table/Fig-5]. For accuracy of data analysis,these patients were divided into two groups; a group confirmed to have IUGR or growth restricted fetus (GRF) and a group not having IUGR. Based on Ponderal Index, 72 cases (72%) were IUGR and 28 cases (28 %) were not IUGR [Table/Fig-6]. Out of 72 cases of IUGR, 50 patients (71%) had caesarean section (CS) and 22 patients (29%) had vaginal delivery (VD) Out of 28 cases not diagnosed as IUGR 8 patients (28%) had CS and 20 patients (72%) had VD [Table/Fig-7].

With UA PI cut-off value taken for IUGR as >1.42, it was found to be 58.3% SS and 71.4% specific (SP) at 30 weeks of GA, with a positive predictive value (PPV) and negative predictive value (NPV) of 84.0 and 40.0%, respectively. At 33 weeks of GA, the sensitivity increased to 72.2%; and specificity marginally declined to 64.2%, while PPV and NPV were 83.8 and 47.3%, respectively. On the 3rd visit at 36 weeks of GA, the sensitivity was 75.0%, while specificity was 85.7%. The PPV and NPV were 93.1 and 57.1%, respectively. The overall diagnostic accuracy of the test was 70.0% With UA RI cut-off value for IUGR being taken as >0.72, it was found that at 30 weeks of GA it was 55.5% SS and 85.7% SP, with PPV of 90.9 and NPV of 42.8%. At 33 weeks there was an increase in sensitivity to 63.8% and marginal decline of specificity to 82.1%, with PPV and NPV of 90.1 and 46.9%, respectively. On the 3rd visit at 36 weeks, the sensitivity was 66.6%, and specificity was 89.2%. The PPV was 94.1 and NPV was 51.0% [Table/Fig-8,9]. The overall diagnostic accuracy of the test was 54.0%.

GA in weeks	Pulsality Index (PI)				Resistive Index (RI)			
	GRF (N=72)		No IUGR (n=28)		GRF (n = 72)		No IUGR (n = 28)	
	>1.42	<1.42	>1.42	<1.42	>0.72	<0.72	>0.72	<0.72
	TP	FN	FP	TN	TP	FN	FP	TN
30	42	30	8	20	40	32	4	24
33	52	20	10	18	46	26	5	23
36	54	18	4	24	48	24	3	25
Total	148	66	22	62	134	82	12	72

[Table/Fig-8]: Diagnostic efficiency of Umbilical artery PI and RI at different gestational age intervals
TP:True Positve, TN:True Negative, FP:False Positive, FN:False Negative GRF: Growth Resctricted Fetus

GA in weeks	Pulsality Index (PI)				Resistive Index (RI)			
	GRF (N=72)		No IUGR (n=28)		GRF (n = 72)		No IUGR (n = 28)	
	>1.42	<1.42	>1.42	<1.42	>0.72	<0.72	>0.72	<0.72
	SS	SP	PPV	NPV	SS	SP	PPV	NPV
30	58.3	71.4	84.0	40.0	55.5	85.7	90.9	42.8
33	72.2	64.2	83.8	47.3	63.8	82.1	90.1	46.9
36	75.0	85.7	93.1	57.1	66.6	89.2	94.1	51.0

[Table/Fig-9]: Sensitivity (SS), specificity (SP), Positive Predictive Value (PPV) and Negetive Predictive Value (NPV) of Umbilical artery PI and RI at same gestational age intervals
Overall diagnostic accuracy of PI of Umbilical artery : 70%
Overall diagnostic accuracy of RI of Umbilical artery : 54%

GA in weeks	Pulsality Index (PI)				Resistive Index (RI)			
	GRF (N=72)		No IUGR (n=28)		GRF (n = 72)		No IUGR (n = 28)	
	>1.5	<1.5	>1.5	<1.5	>0.59	<0.59	>0.59	<0.59
	TP	FN	FP	TN	TP	FN	FP	TN
30	47	25	6	22	47	25	8	20
33	54	18	2	26	46	26	6	22
36	56	16	3	25	52	2	4	24
Total	157	59	11	73	145	71	18	66

[Table/Fig-10]: Diagnostic efficiency of Middle cerebral artery PI and RI at different gestational age intervals
TP:True Positve, TN:True Negative, FP:False Positive, FN:False Negative GRF: Growth Restricted Fetus

GA in weeks	Pulsality Index (PI)				Resistive Index (RI)			
	GRF (N=72)		No IUGR (n=28)		GRF (n = 72)		No IUGR (n = 28)	
	>1.42	<1.42	>1.42	<1.42	>0.72	<0.72	>0.72	<0.72
	SS	SP	PPV	NPV	SS	SP	PPV	NPV
30	65.2	78.5	88.6	46.8	65.2	75.2	85.4	55.5
33	75.0	92.8	92.8	59.0	63.8	78.5	88.4	45.8
36	77.7	80.6	90.3	60.9	72.2	85.7	92.8	54.5

[Table/Fig-11]: Sensitivity, specificity, PPV and NPV Middle cerebrel artery PI and RI at same gestational age intervals
Overall diagnostic accuracy of PI of Middle cerebral artery : 76.6%
Overall diagnostic accuracy of RI of Middle cerebral artery : 70.3%

S.no.	Doppler findings	Cases	Delivery Mode	Reduced Apgar Score	NICU Admission	Perinatal Death
1.	UA RI/PI raised (abnormal)	50	VD: 12	10	10	2
			CS: 35	7	7	1
2	MCA RI/PI reduced (abnormal)	22	VD: 10	5	5	1
			CS: 15	4	4	-
3	UA artery flow normal	20	VD: 15	2	2	-
			CS: 5	1	1	-
4	MCA flow normal	8	VD: 5	1	1	-
			CS: 3	-	-	-

[Table/Fig-12]: Perinatal outcome with respect to PI and RI values of UA and MCA
CS: Caesarean Section, VD: vaginal delivery

For the MCA PI, the cut-off value was taken as <1.5. At 30 weeks of GA, it was noted to be 65.2 % SS and 78.5 % SP with, a PPV of 88.6 % and a NPV of 46.8 %. At 33 weeks, there was a marginal increase in sensitivity to (75.0 %) and specificity to 92.8%, with PPV of 96.4% and NPV 59.0 %. At 36 weeks of GA, the sensitivity was 77.7 %, specificity 80.6 %, PPV 90.3 % and NPV was 60.9 %. Overall, diagnostic accuracy of the criteria was 76.6%. For the MCA RI, the cut-off value for IUGR was taken as < 0.59. At 30 weeks of GA sensitivity was 65.2 %, specificity 75.2%, PPV 85.4 % and NPV of 55.5 %. At 33 weeks of GA the sensitivity declined to 63.8 %. Its specificity was 78.5%, PPV was 88.4 % and NPV was 45.8 %. At 36 weeks of GA the sensitivity was 72.2%, specificity 85.7%. Its PPV was 92.8% and NPV was 54.5 %, [Table/Fig-10-12].

Overall diagnostic accuracy of the criteria was 70.3%. Out of 72 cases of IUGR, 50 cases underwent CS and 22 cases had vaginal deliveries. Of these 26 cases had Apgar score less than 7 at 5 minutes and all had NICU admissions of which there were 4 perinatal deaths. Out of 28 cases not diagnosed as IUGR, 8 cases underwent CS and 20 cases had vaginal deliveries. Of these, 4 cases had Apgar score less than 7 at 5 minutes and all were admitted to NICU. There was no perinatal death in this group.

DISCUSSION

IUGR is a condition in which fetus does not reach its normal growth potential. An adequate fetal circulation is necessary for its normal growth. With advancing GA, changes occur in the maternal, placental and fetal vasculatures for facilitating the fetus to achieve its true growth potential. Abnormal haemodynamics in utero-placental and feto-placental circulation leads to this condition. Doppler waveform analysis has a big role in the diagnosis of placental insufficiency and in detection and management of IUGR.

This study was done to see the accuracy of PI and RI of the UA and MCA in predicting IUGR. Of all these vessels studied in Doppler, UA is the first and the most well studied. Normally S/D ratio, PI, and RI, decrease with

advancing GA. But, in IUGR, at first there is decreased diastolic flow in the UA due to increase in the resistance in small arteries and arterioles of the tertiary villi [7]. This raises the S/D ratio, PI, and RI of the UA which can be picked up by Doppler. The absence of diastolic flow is often associated with adverse outcome of pregnancy, for example IUGR and fetal hypoxia. Absent or reversed diastolic blood flow in UA velocity shows strong correlation with fetal hypoxia and acidosis, Tannirandorn and Phaosavasdi [8].

In the present study the observed UA PI had a sensitivity and specificity of 58.3 and 71.4 % at 30 weeks, 72.2 and 64.21 % at 33 weeks, and 75.5 and 85.7 % at 36 weeks, respectively. Overall, the sensitivity of the criteria was 68.5 %, specificity was 73.7 %, PPV was 86.9 %, and NPV was 48.1 %. The overall diagnostic accuracy of the test was 70.0 %.

In the present study we saw a high sensitivity, specificity and high positive predictive and NPV. North et al., [9] reported a sensitivity of 47% and a specificity of 91% for prediction of IUGR. In our study, a relatively higher diagnostic efficacy was achieved, though the specificity was lower as compared to that of North et al., yet the sensitivity was quite high.

In the study of Kurmanavicius et al., [5], the 95% percentile value of RI for UA at 30 weeks was found to be 0.9. In the present study observations are similar to that of Mulders et al., [10], who found a sensitivity of 53.3 % and a specificity of 87.9 % for the UA PI at around 32–34 weeks of pregnancy. In the present study, by the 3rd visit at 36 weeks of GA, diagnostic efficacy improved for all the indices like it sensitivity, specificity, PPV, and NPV. Review of literature says that PI decreases initially and then increases with advancing GA and it is in its peak towards term pregnancy, hence this criteria becomes more SS. But in cases with placental insufficiency with high resistance flow, the diastolic flow decreases and it results in a higher PI value [7] there by increasing the specificity with advancing pregnancy. In the present study, we observed the overall diagnostic accuracy of the UA PI to be 70 %. In a similar study, Lakhkar and Ahamed [11] reported a sensitivity of 44.4 %, specificity of 81.8 %, PPV of 80 %, and NPV of 47.3 % for predicting any major adverse outcome including neonatal IUGR among pregnancies beyond 30 weeks of gestation and complicated by severe preeclampsia and IUGR or both.

In the present study, the UA RI was found to have a marginally lower efficacy as compared to the UA PI. One of the conclusions drawn in a study by Bano et al., [12] was that the UA PI can be used to identify IUGR per se, and the MCA PI alone is not a reliable indicator for predicting fetal distress.

In this study for UA RI overall, the sensitivity was 61.9 % and specificity was 85.6 %, PPV of 91.7 and NPV of 46.9%. Its overall diagnostic accuracy was 54%. In the present study, for MCA PI the data generated showed overall sensitivity of 72.6%, specificity of 83.9%, PPV of 91.7%, NPV of 55.5. Maximum specificity of 92.8% was noted at 33 weeks of GA. Overall diagnostic accuracy was 76.6%. It has been reported by Kurjak et al., [13] that brain sparing effect of fetal circulation is frequently responsible for severe retardation of body rather than that of head. For MCA RI the overall sensitivity of 67.0%, specificity of 79.8, PPV of 88.8, NPV of 51.9 . Overall diagnostic accuracy was 70.3%. It is to be noted that in our study the standardized cut of values of PI and RI for UA and MCA were fairly accurate and comparable in prediction of IUGR and accuracy of both the vessels increased with advancing GA.

CONCLUSION

The following conclusions were drawn from the present study. The incidence of clinically confirmed IUGR was 72%. The cut of values used for indices like PI and RI for UA and MCA were accurate in prediction of IUGR and were reproducible. There sensitivity and specificity increased with advancing GA, reflecting truly the increase in high resistance flow in utero-pacntal bed and brain sparing effect in fetus in cases of IUGR Overall diagnostic accuracy of UA PI was 70%,UA RI was 54%, MCA PI was 76.6% and MCA RI was 70.3 %. There were more incidence of CS (71%) in IUGR cases than non IUGR cases (29%). Rate of adverse perinatal outcome like low Apgar score below 5 at 7 minutes and admission to NICU was high in IUGR group (36%) and less (13%) in non IUGR group. So we conclude that Doppler velocimetry is an effective and non invasive tool which can detect the abnormal haemodynamics of utero-placental and fetal blood flow early in gestation with high degree of accuracy. This can predict the cases of IUGR early and hence help in their proper management, thereby decreasing the perinatal morbity and mortality.

REFERENCES

[1] Battaglia FC, Lubchenco LO. A practical classification of newborn infants by weight and gestational age. *J Pediatr.* 1967;71:159.

[2] Manning FA, Hohler C. Intrauterine growth retardation: diagnosis, prognostication, and management based on ultrasound methods. In: Fleischer AC, et al., eds. The principles and practice of ultrasonography in obstetrics and gynecology. 4th ed. Norwalk, Conn.: *Appleton & Lange*, 1991:331–48.

[3] Craigo SD. The role of ultrasound in the diagnosis and management of intrauterine growth retardation. *Semin Perinatol*. 1994;18:292–304.

[4] Arduini D, Rizzo G. Prediction of fetal outcome in small for gestational age fetus: comparison of Doppler measurements obtained from different fetal vessels. *J Perinat Med*. 1992;20: 29–38.

[5] Kurmanavicius J, Florio I, Wisser J, Hebisch G. 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.

[6] Bahlmann F, Reinhard I, Krummenauer F, Neubert S, Macchiella D, Wellek S. Blood flow velocity waveforms

of the fetal middle cerebral artery in a normal population: reference values from 18 weeks to 42 weeks of gestation. *J Perinat Med*. 2002;30:490.

[7] Gudmundsson S, Marsal K. Umbilical artery and uteroplacental blood flow velocity waveforms in normal pregnancy—a cross sectional study. *Eur J Obstet Gynaecol*. 1988;67(4):347–54.

[8] Tannirandorn Y, Phaosavasdi S. Significance of an absent or reversed end-diastolic flow velocity in Doppler umbilical artery waveforms. *J Med Assoc Thai*. 1994 Feb;77(2):81–86.

[9] 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.

[10] Mulders LG, Wijn PF, Jongsma HW, Hein PR. 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.

[11] Lakhkar BN, Ahamed S. Doppler velocimetry of uterine and umbilical arteries during pregnancy. *Indian J Radiol Imaging* 1999; 9(3): 119-215.

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

[13] Kurjak A, Kirkinen P, Latin V. Biometric and dynamic ultrasound assessment of small for dates infants. *Obstet Gynaecol*. 1980;56(3):281–84.

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