Predictive Accuracy of Doppler Systolic/Diastolic Ratio of Umbilical Artery for Evaluation of IUGR in 3rd Trimester

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Abstract:

Intrauterine Growth Restriction (IUGR) is an important multifactorial obstetric and neonatal problem worldwide especially in Pakistan. It is defined as failure of the fetus to achieve its genetically predetermined growth potential and has sonographic estimated fetal weight below 10th percentile for that particular gestational age. IUGR fetus has abnormal sonographic fetal biometry and Doppler parameters.

Objective:

To determine the predictive accuracy of doppler Systolic/Diastolic ratio of Umbilical Artery for Evaluation of IUGR in 3rd trimester

Methods:

A cross-sectional (predictive) study was conducted in Clinical Radiology Department of University of Lahore (UOL) teaching Hospital Lahore. Total 70 singleton pregnant women, among them 35 normotensive pregnant women in control group and 35 hypertensive pregnant women in study group, in 3rd trimester were recruited. Sonographic fetal biometry was done and Systolic/Diastolic (S/D) Ratio of Umbilical Artery (UA) Doppler was measured for evaluation of IUGR fetuses.

Results:

Systolic/Diastolic (S/D) Ratio of Umbilical Artery Doppler showed sensitivity 85.71%, specificity 80%, Positive predictive value (PPV) 81.08%, and Negative predictive value (NPV) 84.85 % and diagnostic accuracy 82.86%, when S/D Ratio ≥ 3 was considered abnormal for evaluation of IUGR in pregnancy induced hypertension (PIH).

Conclusion:

Measurement of Umbilical Artery Doppler Systolic/Diastolic Ratio for investigation of fetal circulation is a valuable predictor for evaluation of IUGR. Hence it may be used along with conventional sonographic fetal biometry in surveillance of fetal growth and wellbeing in 3rd trimester of pregnancy.

Keywords:

IUGR, PIH, Fetal Biometry, Umbilical Artery Doppler S/D Ratio.

Introduction:

Intrauterine Growth Restriction (IUGR) is an important multifactorial obstetric and neonatal problem worldwide especially in Pakistan.[1] IUGR was formerly known as intrauterine growth retardation.[2] It is defined as failure of the fetus to achieve its genetically predetermined growth potential and has sonographic estimated fetal weight below 10th percentile for that particular gestational age.[3] In precisely dated pregnancies approximately 80-85% 0f fetuses identified as being IUGR are constitutionally small but healthy fetuses, 10-15% are true IUGR.[1] However the true incidence of IUGR in Pakistan remains unknown because most of deliveries occur at home or up to 91% of the infants are not weighed at birth.[4] The prevalence of IUGR in Pakistan is 25%[5]. Fetal growth restriction is identified as one of the most common causes of still birth.[6] The primary cause of IUGR in normally formed fetus is placental insufficiency[7] and the most important and common cause of placental insufficiency is pregnancy induced hypertension (PIH) or

preeclampsia. Pregnancy induced hypertension is characterized by high B.P after 20 weeks of gestation which is often accomplished with proteinuria.[8] Preeclampsia is associated with risks to both mother and fetus.[9] IUGR fetuses have abnormal fetal biometry and Doppler parameters but there is interobserver variability. Fetal sonographic biometry is a sensitive technique for evaluation of IUGR but Umbilical Artery Doppler velocimetry is a valuable adjunct for improving the diagnostic accuracy for the prenatal identification and monitoring of IUGR. Preeclampsia or pregnancy induced hypertension (PIH) is a serious multisystem disorder of pregnancy. It is defined as B.P >140/90 mm of Hg, mild/moderate preeclampsia as B.P>140/90 mm of Hg in the presence of ≥ 0.3g albumen/ 24 hours urine specimen. Severe preeclampsia is defined as diastolic B.P ≥ 110 mm of Hg and ≥ 0.3g albumen/ 24 hours urine specimen. Preeclampsia should be suspected in any pregnant woman with hypertension even if proteinuria is absent.[10] In hypertensive pregnancy the main complication of fetus is the asymmetric type of IUGR and Oligohydramnios. A small thinner placenta as compare to the normal for given gestational age is a characteristic of uteroplacental insufficiency.[11] IUGR fetuses are classified as symmetric and asymmetric in term of their body proportions.[12] Symmetrical or primary growth restriction is also known as intrinsic, non-nutritional growth restriction. In this condition an intrinsic fetal problem causes growth restriction. Chromosomal anomalies and intrauterine infections are the causative factors. Symmetric IUGR has early onset and is characterized by all internal organs being reduced in size i.e. there is equally poor growth of head, long bones and abdomen. On ultrasound examination all parameters are <10 percentile. HC/AC ratio is within normal limits. Asymmetrical or secondary growth restriction is also known as extrinsic, nutritional growth restriction. Fetus is

intrinsically normal but oxygen and nutrition is deprived due to problem with maternal circulation or placenta, resulting in an inadequate or even absent growth of AC. There is redistribution of blood to the brain in severe cases known as brain sparing phenomenon so brain and head continue to grow about normally. Fetal head and long bones are spared compared with their intra- abdominal viscera. HC/AC, FL/AC ratio is distributed. It is noticed after 28 weeks.[13] Standard sonographic fetal biometry measurements of Bi-parietal Diameter (BPD), Head circumference (HC), abdominal circumference (AC), Femur Length (FL) are done for dating a pregnancy or for estimation of intrauterine fetal weight ((EFW). A growth restricted fetus will have diminished AC, but normal HC measurement. HC/AC Ratio is a better predictor in asymmetric IUGR. In this case there is an increased ratio of HC/AC. It is normally one at 32-34 weeks and falls below one (<1) at 34 weeks. HC/AC ratio greater than one (>1) after 34 weeks detects about 85% of IUGR cases.[14]

For obstetric Doppler Ultrasound several impedence indices such as systolic to diastolic (S/D) Ratio, resistance index (RI) and Pulsitility index (PI) are used most commonly in third trimester of pregnancy for evaluation and follow up of high risk pregnancies associated with placental insufficiencies. In placental mammals, the umbilical cord is a cord between fetus and placenta, where blood circulates through vessels. It contains two Umbilical arteries and one Umbilical vein. Doppler Ultrasound is of value in enabling the umbilical artery waveform to be sampled rapidly and accurately. Umbilical Artery Doppler should be done during a period of fetal inactivity and apnea. End Diastolic flow (EDF) is normally absent in first trimester.[15] With advancing gestational age there is gradual Physiologic increase in peak systolic velocity and end diastolic velocity. In IUGR due to defective trophoblastic invasion of vascular channels there is damage to placental territory stem villi. There

is increased Placental vascular resistance causing progressive decrease in end diastolic flow, consequently all indices, RI, PI, S/D Ratio increase until absent end diastolic flow (AEDF) and the reversed end diastolic flow (REDF) is evident and this is commonly associated with severe IUGR and Oligohydramnios. The purpose of the study is to established the diagnosis of IUGR through doppler systolic / diasystolic ratio of umbilical artery, so that if there is any complication during pregnancy, it may be controlled.

Methods:

A cross-sectional (predictive) study was conducted on 70 patients at Clinical Radiology Department of University of Lahore (UOL) Teaching Hospital Lahore. The patients who attended the Gynaecology OPD (Out Patient Department) with properly maintained antenatal cards or were admitted in Obstetric Ward of University of Lahore (UOL) Teaching Hospital Lahore were assigned to control and study group. In control group 35 normotensive singleton pregnant women and in study group 35 hypertensive singleton pregnant women in 3rd Trimester (gestational age 30-40 weeks), primigravida and multigravida were recruited according to their inclusion criteria. While patients with Multiple Pregnancy, Fetal Congenital Anomalies or were suffering from any chronic illness which can affect fetal growth were not included in the study. Conventional sonographic fetal biometry and Umbilical Artery Doppler Ultrasound was performed on LOGIC P6 and Toshiba Xerio x4 with convex probe of frequency 3-5 MHz on eligible patients. Demographic and Obstetric data was documented according to the variables of maternal age, parity, GA (gestational age) calculated by LMP and by Ultrasound, HC/AC Ratio, EFW (gm), AFI (cm), S/D Ratio of Umbilical Artery Doppler, on data collection sheet. The collected data was compiled and tabulated in Microsoft excel sheet. Data analysis was done with the help of SPSS Version 22.

Results were presented in the form of mean ± S.D and percentages. The Sensitivity (%), Specificity (%), Positive Predictive Value (%), Negative Predictive Value (%), and Diagnostic Accuracy (%) of Umbilical Artery Doppler SD Ratio was calculated.

Results:

The mean maternal age of 35 IUGR Positive patients with Standard Deviation (S.D) was 29.37± 5.39 years and of 35 IUGR Negative patientswas 28.17 ± 4.29 (P-Value 0.307). The mean GA (Gestational age) calculated by LMP in IUGR Positive patients with S.D was 34.40 ± 2.39 weeks and 3.29 ± 1.90 days and in IUGR Negative patients was 33.97 ± 2.97 weeks and 3.40 ± 2.14 days (P-value 0.508), Table 1.

Descriptive Statistics	IUGR	N	Mean	S.D	p-value
Age (years)	Positive	35	29.37	5.39	0.307
	Negative	35	28.17	4.29	
GA by LMP (weeks)	Positive	35	34.40	2.39	0.508
	Negative	35	33.97	2.97	
GA by LMP (days)	Positive	35	3.29	1.90	0.814
	Negative	35	3.40	2.14	

Table1: Descriptive Statistics of AGE (years) and GA by LMP in weeks and days in both groups

The mean estimated fetal weight (gm) of IUGR Positive fetuses with S.D was 1923.46 ± 507.51 and of IUGR Negative fetuses was 2371.29 ± 712.45 (P-Value 0.003)
The mean HC/AC ratio of IUGR Positive fetuses with S.D was 1.10 ± 0.08 and of IUGR Negative fetuses was 1.01 ± 0.03 (P-Value < 0.001).
The mean AFI (cm) of IUGR Positive fetuses with S.D was 8.94 ± 2.81 and of IUGR Negative fetuses was 16.03 ± 2.47 (P-Value < 0.001).
The mean Umbilical Artery Doppler SDR (Systolic/Diastolic Ratio) of IUGR Positive fetuses with S.D was 4.07 ±1.19 and in IUGR Negative fetuses was 2.40 ± 0.52 (P-Value < 0.001), Table 2

Descriptive Statistics	IUGR	N	Mean	S.D	p-value
EFW (g)	Positive	35	1923.46	507.51	<0.003
	Negative	35	2371.29	712.45	

HC/AC (Ratio)	Positive	35	1.10	2.39	<0.001
	Negative	35	1.01	0.08	
AFI (cm)	Positive	35	8.94	2.81	<0.001
	Negative	35	16.03	2.47	
SD (Ratio)	Positive	35	4.07	1.19	<0.001
	Negative	35	2.40	0.52	

Table 2: Descriptive Statistics of EFW (gm), HC/AC Ratio, AFI (cm) and SD Ratio in both Groups

Out of total 70 participants 17 females have 0 Parity with percentage (24.29%), Para 1 were 11 in numbers with percentage (15.71%), Para 2 were 20 in numbers with percentage (28.57%), Para 3 were 13 in numbers with percentage (18.57%), Para 4 were 9 in numbers with percentage (12.86 %), Figure 1
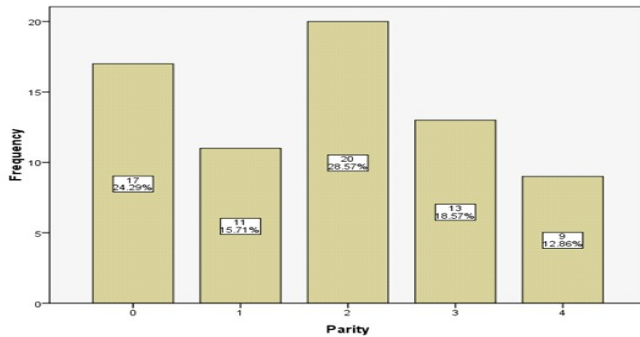

Figure 1: Frequency and Percentage Distribution of Parity among all Participants

Out of total 70 participants 37 had abnormal umbilical artery Doppler SD (Ratio) with percentage (52.86%) and 33 participants had normal SD (Ratio) with percentage (47.14%), Figure 2.
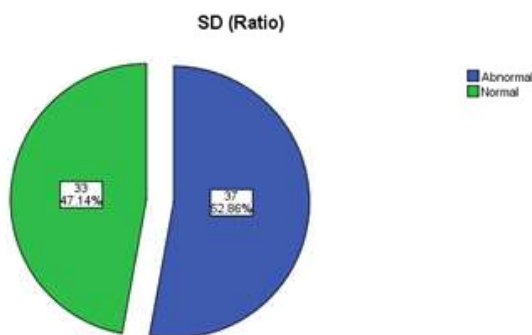

Figure 2: Percentage Distribution of SD Ratio in all participants

Among total 35 (50.0%) IUGR Positive cases in study group, 30 cases (42.9%) showed abnormal Umbilical Artery Doppler SDR and 5 cases (7.1%) showed normal SDR. Among total 35 (50.0%) IUGR Negative cases in control group, 28 (40.0%) cases showed normal SDR and 7 (10.0%) showed abnormal SDR. Table 3

		IUGR		Total
		Positive	Negative	
SD (Ratio)	Abnormal	30	7	37
		42.9%	10.0%	52.9%
	Normal	5	28	33
		7.1%	40.0%	47.1%
Total		35	35	70
		50.0%	50.0%	100.0%

Table 3: Diagnostic accuracy of SD (Ratio) taking IUGR as Gold Standard

Umbilical Artery Doppler S/D Ratio showed sensitivity 85.71%, specificity 80%, positive predictive value 81.08% and negative predictive value 84.85% with diagnostic Accuracy of 82.86% when S/D Ratio 3 or more than 3 was considered abnormal. Table 4

Parameter	Estimate	Lower - Upper 95% CIs
Sensitivity	85.71%	(70.62, 93.74)
Specificity	80%	(64.11, 89.96)
Positive Predictive Value	81.08%	(65.79, 90.52)
Negative Predictive Value	84.85%	(69.08, 93.35)
Diagnostic Accuracy	82.86%	(72.38, 89.91)

Table 4: Prognostic Efficacy of Umbilical Artery SDR ≥ 3

Discussion:

Doppler ultrasound is a safe clinical tool for quantitative analysis of uteroplacental and fetoplacental blood flow in pregnancy. Evaluation of normal Doppler indices in the Umbilical Artery of healthy pregnant woman serves as baseline values in predicting impaired blood flow velocimetry in pregnancy induced hypertension (PIH) or preeclampsia that leads to serious maternal and fetal health compromise.

As IUGR worsens UA Doppler abnormalities also deteriorate. In present study sonographic fetal biometric parameters such as EFW (gm), AFI (cm) HC/AC Ratio had been found to have statistically significant different mean ± S.D in IUGR Positive as compared with IUGR Negative fetuses (1923.46 ± 507.51 vs. 2371.29 ± 712.45; P 0.003, 8.94 ± 2.81 vs. 16.03 ± 2.47; P < 0.001, 1.10 ± 0.08 vs. 1.01 ± 0.03; P < 0.001). Mean value of EFW and AFI in IUGR was lower than in normal fetus. Mean value of HC/AC Ratio in IUGR was higher than in normal fetus.

Ranjan K. Sahoo,(2015) had similar statistically significant different mean ± S.D of EFW (gm), AFI (cm), and HC/AC Ratio in IUGR and normal fetuses (1783.83 ± 479.43 vs. 2731 ± 306.7; P < 0.0001, 4.9967 ± 2.1573 vs. 11.10 ± 1.99; P < 0.0001, 1.2007 ± 0.07 vs. 1.0745 ± 0.07; P < 0.0001). In their study Umbilical Artery showed 73% Sensitivity, 85% Specificity, 35% Positive Predictive Value and 96% Negative Predictive Value when SDR was more than 3. Although Sensitivity and PPV was lower than present study but have higher Specificity and NPV for evaluation of IUGR.[16]

A study done by Mrina Gaywali Sharma P, (2015) showed the sensitivity, specificity, positive predictive value and negative predictive value, 76%, 76.91%, 79.2%, and 73.5% respectively when S/D Ratio was 3 or more than 3. It was found that abnormal S/D Ratio was a good predictor of IUGR and neonatal outcome.[17] Their study findings are comparable to the present study.[17] A similar study made by Chanprapaph Tongsong T and Siriaree S (2014) showed the sensitivity 67.71%, Specificity 78.85%, Positive predictive value 74.42% and Negative predictive value 65.08% .The value are less to some extent than present study because Fetal biometry and Doppler parameter calculations had inter observer variability but the results are helpful to determine the prognostic efficacy of Umbilical Artery Doppler in evaluation of IUGR.[18]

Deepti D.Sharma KCC. (2016) reported that S/D Ratio of 3 or greater had sensitivity 59.3%, Specificity 81%, and Positive predictive value 82%, Negative predictive value 58%. It was evaluated that Umbilical Artery S/D Ratio > 3 was a definite predictor of IUGR but absent end diastolic flow(AEDF) and reversed end diastolic flow (REDF) in Umbilical Artery was specifically associated with poor neonatal morbidity and mortality.[19] Similarly the present study concluded that Umbilical Artery Doppler had high accuracy for antenatal fetal surveillance in pregnancy induced hypertension (PIH) and IUGR. According to Bhimeswararao Pasupuleti study (2015), 33/50 (66%) cases showed abnormal S/D Ratio consistent with IUGR when S/D Ratio > 3 after 30 weeks of Gestation was considered abnormal .The remaining 17/50 (34%) cases did not show any evidence of IUGR. The Umbilical Artery showed 62% Sensitivity in predicting the IUGR. It was also found that 7/50 cases had absent end diastolic flow (AEDF) and 4/50 cases showed reversed end diastolic flow (REDF). In present study 3/35 cases had AEDF and 5/35 cases showed REDF. It was concluded that Umbilical Artery Doppler Waveform study especially AEDF and REDF were sensitive parameters to identify IUGR fetuses at high risk of perinatal complications.[20]

Conclusions:

According to this study it is concluded that abnormal Systolic/Diastolic (S/D) Ratio of Umbilical Artery Doppler velocimetry is a good predictor of IUGR in Pregnancy induced hypertension (PIH) in third Trimester. This provides timely obstetric intervention to prevent progression from IUGR to intrauterine death.

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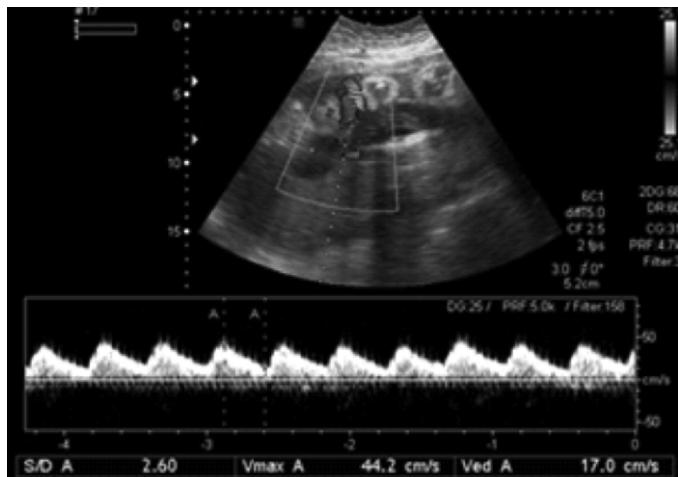
Figure 3: Systolic/Diastolic ratio of Umbilical Artery Doppler in IUGR Negative case
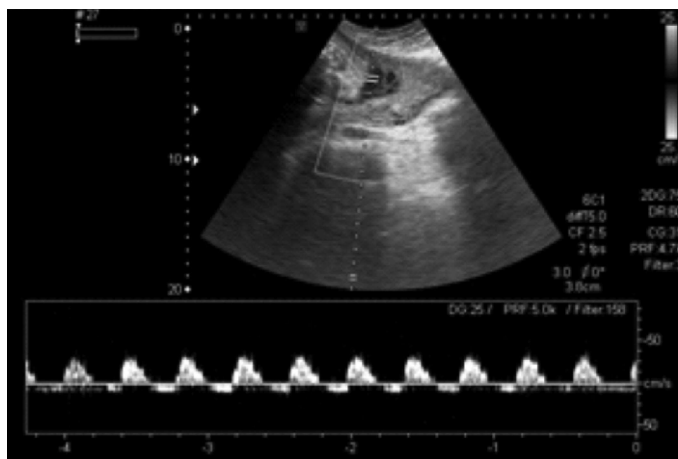

Figure 4: Reversed end diastolic flow (REDF) of Umbilical Artery Doppler in IUGR Positive case