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Umbilical Artery Doppler Flow Velocimetry in IUGR And its Relation to Perinatal Outcome

Faryal Qureshi[1], Muhammad Nafees[1], Aamna Javaid[1], Irum Taqi[1], Fawad Gohar Bukhari[1]

[1]Department of Radiology, PAF Hospital, Islamabad, Pakistan.

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Correspondence to: Faryal Qureshi, Department of Radiology, PAF Hospital Islamabad, Pakistan.
Email: faryal.qureshi@hotmail.com

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ABSTRACT

Background: Intrauterine growth restriction (IUGR) is one of the leading causes of perinatal morbidity and mortality, and it is mostly caused by placental insufficiency. Umbilical artery (UA) Doppler velocimetry is a non-invasive tool used to determine fetoplacental circulation and identify fetuses who are at risk of poor outcomes. Objectives of this study are to 1) determine the frequency of abnormal umbilical artery Doppler velocimetry in pregnancies complicated by IUGR and 2) evaluate the frequency of perinatal outcomes in the cases with abnormal Doppler findings. **Material and Methods:** This hospital-based descriptive cross-sectional study was carried out on 149 pregnant women with the diagnosis of IUGR with a gestational age of at least 28 weeks. Umbilical artery Doppler examination was done for the categorization into normal and abnormal. Patients were followed up till delivery and perinatal outcomes such as mode of delivery, low birth weight, preterm birth, Apgar score at 5 minutes, admission to the neonatal intensive care unit and neonatal death were recorded. Data were analyzed with the help of the SPSS 25.0 and frequencies and percentages were obtained. Study confounders were controlled through stratification; chi-square and Fisher exact test was applied and p-value ≤0.05 considered as significant. **Results:** Abnormal umbilical artery Doppler was observed in 61 (40.9%) cases. Compared to the normal Doppler group, abnormal Doppler was significantly associated with higher rates of cesarean delivery (75.4% vs 35.2%), low Apgar score at 5 minutes (39.3% vs 14.8%), low birth weight (60.7% vs 20.5%), preterm birth (29.5% vs 4.5%), and NICU admission (80.3% vs 27.3%) (p<0.05). Neonatal death was higher in the abnormal Doppler group (6.6% vs 1.1%) but did not reach statistical significance (p=0.071). **Conclusion:** Abnormal umbilical artery Doppler velocimetry in IUGR is common and is highly correlated with poor perinatal outcome. Its routine use can help in the early risk stratification and better clinical decision-making and ultimately improve perinatal outcomes.

INTRODUCTION

Fetal growth restriction which is commonly known as intrauterine growth restriction (IUGR) is an important obstetric condition that involves inability of the fetus to reach the genetically determined growth potential [1]. It is associated with significant perinatal morbidity and mortality such as stillbirth, neonatal death, prematurity, hypoxia and long-term neurodevelopmental impairment [2]. In Pakistan, IUGR is responsible for an estimated 20-24% of live births and thus a significant cause of neonatal complications and mortality [3].

The pathophysiological basis of IUGR is most commonly attributed to uteroplacental insufficiency and hence an increase in placental vascular resistance and impaired oxygen and nutrient transfer to the fetus [4]. As a compensatory response, the fetus makes hemodynamic adaptations, such as redirection of blood flow to vital organs, such as the brain and heart. These changes may be well evaluated with the application of Doppler ultrasonography which has become an essential non-invasive tool in the assessment and surveillance of high-risk pregnancies [5,6].

Umbilical artery Doppler velocimetry is specifically related to the placental vascular resistance and gives valuable information about the fetoplacental circulation. Increased resistance within the placental bed causes characteristic changes on the Doppler waveforms with increased pulsatility index (PI), resistance index (RI) and systolic/diastolic (S/D) ratio. In the late stages there can be absent end-diastolic flow (AEDF) or reversed end-diastolic flow (REDF) that have been deemed indicators of severe placental compromise and fetal hypoxia. Such abnormalities as seen on doppler tend to precede clinical deterioration and plays a crucial role in early identification of high risk fetuses [7-9].

Previous studies have shown a close relationship between abnormal umbilical artery Doppler results and poor perinatal outcome. Despite its known clinical value, there is inconsistency in reports of the frequency of abnormal Doppler findings and their associated outcomes in different populations and in various healthcare settings. There is a desperate need for local studies for better understanding of disease patterns and optimize management protocols in resource limited environments.

MATERIAL AND METHODS

The study was a prospective, descriptive cross-sectional study which carried out in the Departments of Radiology in conjunction with Obstetrics and Gynecology Department of PAF Hospital Islamabad between October 2023 to August 2024 after receiving the approval of the Institutional Review Board and CPSP. We enrolled 149 pregnant women in this study, through non-probability consecutive sampling, who were presented with confirmed diagnosis of IUGR. WHO sample size calculator was used for sample size calculation keeping confidence level as 95%, absolute precision as 8% and the expected proportion of the population to be 45% according to the results of Sumathi and Rodrigo [10].

The study included all pregnant women with singleton pregnancies at 28 weeks of gestational age or later and IUGR was diagnosed on ultrasonography (estimated fetal weight or abdominal circumference below the 10th percentile). A valid last menstrual period and /or early ultrasound results were used to calculate gestational age. Patients who had more than one pregnancy, fetuses who had congenital abnormalities, with chromosomal abnormalities, intrauterine fetal death at presentation, and with a doubtful gestational age were excluded.

Informed written consent was obtained and detailed maternal history and clinical examination were done after obtaining informed written consent. The baseline data were gathered on a predesigned proforma, maternal age, parity, gestational age, booking status, and any maternal-related conditions, including hypertension, diabetes mellitus, anemia, oligohydramnios, etc. Obstetric ultrasonography was performed on all the patients with a high-resolution ultrasound machine that had doppler facility and 3.5-5 MHz curvilinear transducer. Measures of fetal biometry (biparietal diameter, head circumference, abdominal circumference and femur length), and the estimated fetal weight were obtained using conventional Hadlock formulae. The volume of amniotic fluid and the placental features were also evaluated.

The patients were put on semi-recumbent position and Umbilical artery Doppler was done. It was found to have a free-floating loop of the umbilical cord and doppler waveforms were recorded in the fetal quiescence state. An optimum insonation angle was maintained and a minimum of three successive homogenous waveforms were recorded. The PI, RI and S/D ratio were measured. The flow of blood at end diastole was also observed. The results of Doppler were classified as abnormal if we observed high indices (PI, RI, or S/D ratio above the 95th percentile at gestational age), absent end-diastolic flow (AEDF) or reversed end-diastolic flow (REDF). The frequency of abnormal umbilical artery Doppler results was determined in all the cases of IUGR. All the patients were monitored till delivery and the perinatal outcomes were noted. Gathered data were entered and analyzed in SPSS version 25.0. Quantitative variables were represented as the mean ±standard deviation whereas the qualitative variables were represented in frequencies and percentages. The rate of abnormal Doppler results and the occurrence rate of different perinatal outcomes among patients with abnormal Doppler were computed.

RESULTS

Among all the enrolled women mean maternal age was 27.99 ± 5.82 years, mean gestational age was 37.54 ± 1.57 weeks, and mean parity was 2.53 ± 1.64. Detailed quantitative analysis of all the numeric variables is illustrated in table 1.

Table 1

Descriptive statistics of quantitative variables

Variable	n	Minimum	Maximum	Mean	±SD
Maternal age (years)	149	18.00	39.00	27.99	5.82
Gestational age (weeks)	149	31.90	39.60	37.54	1.57
Parity	149	0.00	5.00	2.53	1.64
Estimated fetal weight (g)	149	997.00	2697.00	1998.11	399.75
Abdominal circumference (mm)	149	224.80	314.50	270.70	21.51
Pulsatility index	149	0.86	2.49	1.37	0.39
Resistance index	149	0.53	1.04	0.70	0.12
Umbilical artery S/D ratio	149	2.11	8.40	3.66	1.40
Birth weight (g)	149	1145.00	3300.00	2498.17	580.63
Apgar score at 5 min	149	0.00	10.00	7.54	2.15

Study subjects were further categorized in different parity and maternal age groups and we found that most of the women belonged to age group of 25–34 years (54.4%), while 69.8% of women were multiparous (figure 1 and 2).

Figure 1

Distribution of patients in different maternal age groups

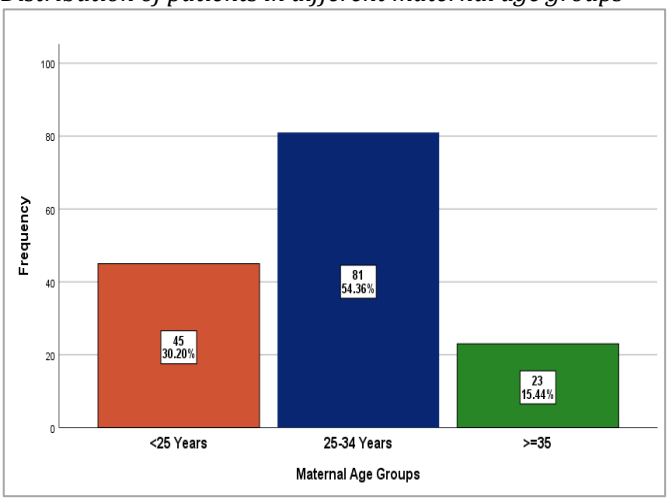
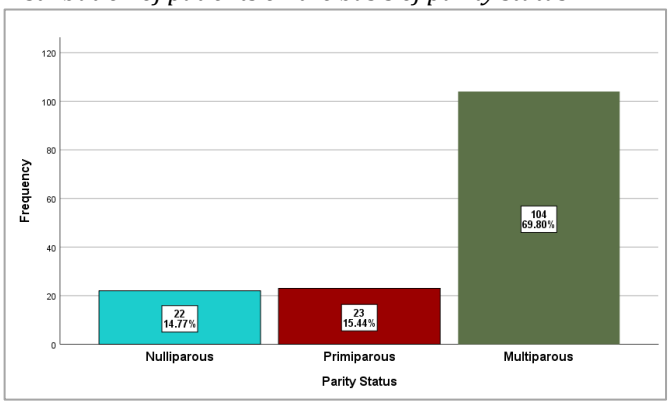


Figure 2

Distribution of patients on the basis of parity status



Abnormal umbilical artery Doppler was observed in 61 of 149 patients (40.9%), whereas 88 patients (59.1%) had normal Doppler findings. Various doppler pattern are graphically presented in figure 3. Cesarean delivery was significantly more frequent in the abnormal Doppler group than in the normal Doppler group (75.4% vs 35.2%, p<0.001). Similarly, low Apgar score at 5 minutes (<7) was more common in patients with abnormal Doppler (39.3% vs 14.8%, p=0.001). Low birth weight occurred in 60.7% of the abnormal Doppler group compared with 20.5% of the normal Doppler group (p<0.001). Neonatal death was numerically higher in the abnormal Doppler group (6.6% vs 1.1%), but this difference did not reach statistical significance (p=0.071). Detailed analysis of perinatal outcomes are illuminated in table 3.

Figure 3

Distribution of various doppler patterns in study population (n=149)

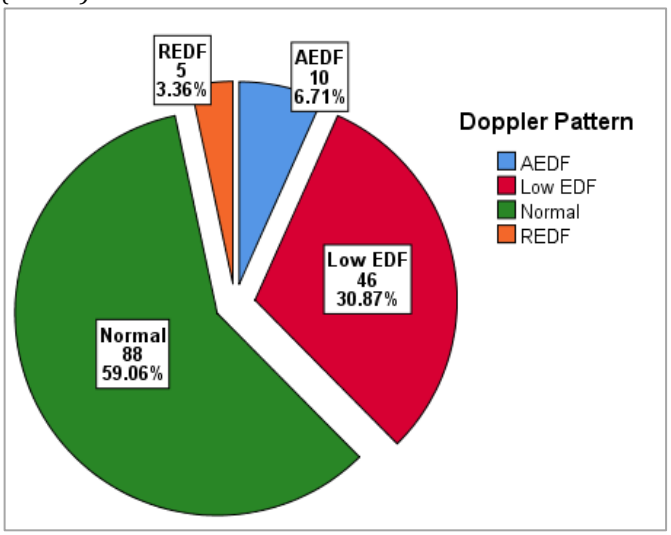


Table 3

Comparison of perinatal outcomes between abnormal and normal Doppler groups

Outcome	Abnormal Doppler n=61	Normal Doppler n=88	*p*-value
Cesarean delivery	46 (75.4%)	31 (35.2%)	<0.001
Apgar score at 5 min <7	24 (39.3%)	13 (14.8%)	0.001
Low birth weight	37 (60.7%)	18 (20.5%)	<0.001
Preterm birth	18 (29.5%)	4 (4.5%)	<0.001
NICU admission	49 (80.3%)	24 (27.3%)	<0.001
Neonatal death	4 (6.6%)	1 (1.1%)	0.071

On stratification, Doppler status was not significantly associated with maternal age group (p=0.126) or parity category (p=0.721). Likewise, most stratified analyses of perinatal outcomes by maternal age and parity were not statistically significant, except for preterm birth across maternal age groups (p=0.021). Overall, adverse perinatal outcomes were consistently more frequent in pregnancies with abnormal umbilical artery Doppler findings. Table 4 and table 5 highlighted the stratification analysis in detail.

Table 4

Stratification of Doppler status by maternal age and parity

Variable		Abnormal Doppler n=61	Normal Doppler n=88	*p*-value
Maternal Age Groups	<25 years	14 (23.0%)	31 (35.2%)	**0.126**
	25–34 years	34 (55.7%)	47 (53.4%)	
	≥35 years	13 (21.3%)	10 (11.4%)	
Parity Status	Nulliparous	8 (13.1%)	14 (15.9%)	**0.721**
	Primiparous	11 (18.0%)	12 (13.6%)	
	Multiparous	42 (68.9%)	62 (70.5%)	

Table 5

Stratified analysis of outcomes by maternal age group and parity status for normal and abnormal doppler findings

Maternal Age Group		Parity Status	
Outcome	***p*-value**	**Outcome**	***p*-value**
Mode of delivery	0.148	Mode of delivery	0.196
Low birth weight	0.134	Low birth weight	0.352
Preterm birth	0.021	Preterm birth	0.926
NICU admission	0.154	NICU admission	0.140
Neonatal death	0.200*	Neonatal death	1.000*
Apgar score at 5 min <7	0.387	Apgar score at 5 min <7	0.346

** Fisher's exact test used due to small cell counts.*

DISCUSSION

The current research shows that abnormal umbilical artery (UA) Doppler velocimetry was observed in 40.9% pregnancy with IUGR, and that such pregnancies were significantly more associated with adverse perinatal outcomes, such as cesarean section, low Apgar score at 5 minutes, low birth weight, preterm birth, and neonatal intensive care unit hospitalization. Such results are biologically plausible, as an abnormal UA Doppler demonstrates greater resistance to the placental vascularity and the inability to perfuse the fetal placenta, which are characteristic of genuine placental insufficiency and not smallness of constitution [11]. Modern definitions and management models underscore the fact that not every fetus with a centile below the 10th percentile is pathologically growth restricted; some are constitutionally small, and the subgroup, with Doppler findings of placental dysfunction, is that with the highest perinatal risk [1,12,13]. This is also the reason why most of our cohort IUGR patients continued with normal UA Doppler results. Moreover, the deteriorated results in the abnormal Doppler group are in line with the known course of placental disease: the more placental resistance, the less fetal supply of oxygen and nutrients, the higher the risk of fetal compromise, cesarean delivery, preterm birth, growth retardation, newborn depression, and the necessity of intensive neonatal care [14,15,16].

Our findings are consistent with the past literature. According to Tolu et al. the outcome of growth-restricted fetuses whose UA Doppler was abnormal was very poor compared to that with normal waveforms, with more of these babies being admitted to NICU and dying shortly after birth, which confirmed the prognostic nature of abnormal fetoplacental flow [17]. Likewise, Ali et al. established that there was a close relationship between abnormal UA Doppler and adverse perinatal outcome in IUGR, and the burden of morbidity and mortality in abnormal Doppler group was significantly higher [18]. Siddiqui et al. also demonstrated that growth-restricted fetuses with lesser end-diastolic flow exerted significantly worse results as compared to fetuses that maintained normal UA flow, which is in line with the idea that severity of diastolic flow abnormality correlates with deteriorating fetal condition [19]. The cesarean section surplus, low birth weight, low 5-minute Apgar score, preterm births, and NICU hospitalization in our abnormal Doppler population, thus, corresponds closely with the already known observational data [17-19]. Though the neonatal death in our abnormal Doppler group was numerically more significant, there was no statistical significance. This is probably an indication that there are relatively few deaths in our cohort, as opposed to no existing relationship since larger studies had indicated a significant increase in perinatal and early neonatal mortality with abnormal UA Doppler, especially in cases where larger end-diastolic flow reverses or does not develop at all [17,18].

These results have clinical implications. UA Doppler is not a risk-stratification instrument, but simply a diagnostic adjunct, in the routine obstetric practice, and removes fetuses with true placental insufficiency as opposed to those merely being small, but otherwise compensated. The difference is very important, as the intensity of management, interval of surveillance, hospitalization, planning of the use of the antenatal corticosteroids, and time of delivery all depend on Doppler status. The ACOG, SMFM and ISUOG offer major guidelines that suggest serial UA Doppler surveillance in fetal growth restriction since deviant waveforms mainly, absent or reversed end-diastolic flow are indicators of advanced placental disease and warrant extra watch and early delivery when clinically justified [20]. This data is justified by our data: the significantly high rates of NICU admission, preterm birth, low birth weight, and operative delivery in the abnormal Doppler cases indicate the idea that UA Doppler can be used to predict a group of IUGR pregnancies that may need a more careful antenatal and intrapartum care. Resource-limited conditions, where advanced fetal surveillance is not necessarily implemented, UA Doppler presents a fairly accessible and clinically significant way of screening high-risk pregnancies.

Limitation of this study however should be viewed in connection with limitations. It was performed at one center and had a relatively small sample size, thereby restricting the generalizability and amounting to low statistical power to rare events like neonatal death. The research method was descriptive cross-sectional followed by delivery making it impossible to infer causation. We also paid specific attention to UA Doppler itself and failed to include other potentially informative measures that include middle cerebral artery Doppler, cerebroplacental ratio, ductus venosus, and composite staging systems which can further refine prognostication in fetal growth restriction. Moreover, we compared only short-term outcomes of perinatality and never considered a longer-term outcome of neonatal/neurodevelopmental outcomes. Future research should thus involve bigger multicentre prospective cohorts, multimodal Doppler based staging and short term as well as long term neonatal outcomes. This kind of work would help to establish the incremental prognostic worthiness of UA Doppler severity designs, especially low end-diastolic flow against insufficient or reverse end-diastolic flow, and would contribute to locally pertinent data on locally applicable management guidelines.

CONCLUSION

According to our study findings, abnormal umbilical artery Doppler velocimetry occurs in a significant percentage of pregnancies affected by IUGR and has a significant correlation with poor perinatal outcomes. Pregnancies with abnormal Doppler results expressed high frequencies of cesarean section, low birth weight, preterm birth, low Apgar scores, and NICU admissions than the ones with normal Doppler. The results support the use of umbilical artery Doppler as a valid, non-invasive method for diagnosing fetuses at risk. Doppler velocimetry can be incorporated in the routine surveillance of IUGR pregnancies to be able to stratify risk early and provide timely obstetric care. This can eventually help in better perinatal outcomes especially in resource-restrained environments. These findings should be proven by further large-scale and multicenter studies that may improve management practices.

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