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Detection of Intrauterine Growth Retardation in 2nd And 3rd Trimester with Fetal Parameters and Umbilical Artery Doppler

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ABSTRACT

Intrauterine Growth Restriction (IUGR) occurs when a fetus fails to reach its growth potential. Ultrasound plays a key role in diagnosis by assessing fetal biometry, and estimated weight. Umbilical artery Doppler studies evaluate placental function, with abnormal findings like increased resistance or absent/reversed end-diastolic flow. **Objective:** To detect Intrauterine growth retardation in 2nd and 3rd trimester with fetal parameters and umbilical artery doppler. **Methods:** This descriptive cross-sectional research took place at Diagnostic centre, Combined Military Hospital, Lahore from September to December 2024. All eligible 130 females in 2nd and 3rd trimester had recruited excluding females with Polyhydromnias. The examination involved the use of a curvilinear transducer (3-5MHz). Non probability convenient technique was employed for data collection. IBM (SPSS) version 26.0 was used for data analysis. For inferential statistics, Chi square test was employed. Statistical p-value <0.05 was considered as a significant value. **Results:** The study involved 130 pregnant women (mean age 28.82 ± 4.64), with 29.2% in the 2nd and 70.8% in the 3rd trimester. IUGR history (25.4%), gestational hypertension (50.8%), and diabetes (19.2%) were noted. IUGR was diagnosed in 52 cases with 3-6week growth delays. Abnormal PI values in all cases confirmed PI as a reliable marker. **Conclusions:** In conclusion, fetal biometric parameters (BPD, HC, AC, FL) below the 10th percentile indicated IUGR in over one-third of 2nd and 3rd trimester pregnancies, with growth lags of 15–43 days. Abnormal umbilical artery Doppler PI was present in all IUGR cases, highlighting PI as a consistent and reliable detection marker.

INTRODUCTION

Intrauterine Growth Restriction (IUGR) is a clinical definition applied to neonates born with clinical features of malnutrition and in-utero growth retardation irrespective of their birth weight percentile [1]. A Doppler ultrasound is a non- invasive technique utilized to approximate blood flow within blood vessels. This is achieved by leading high-frequency sound waves (ultrasound) toward flowing red blood cells and analyzing the resultant echoes [2]. A standard ultrasound examination includes sizes of Biparietal Diameter (BPD), Head Circumference (HC), Abdominal Circumference (AC), Femur Length (FL), Estimated Fetal Weight (EFW), assessment of Amniotic Fluid Index (AFI) [3]. The fetal Umbilical Artery (UA) provides a site of velocimetric studies as Doppler indices Pulsatility Index (PI), resistive index, and Systolic/Diastolic (S/D) ratio evaluates the impedance to the flow through them. An abnormal UA Doppler is therefore an indicator of fetal peripheral vasoconstriction, hence reduced fetal oxygenation. UA Doppler study therefore helps in identifying a compromised fetus, thus reducing adverse perinatal outcomes including mortality [4]. Similar characteristics are shown in figure 1. The incidence is around 3–9% in higher socioeconomic group, whereas the rate is as high as 30% in low socioeconomic group. Almost 20–50% stillborns are growth retarded. After prematurity, this is the second commonest cause for perinatal mortality

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[5]. Intra-uterine growth restriction is frequently a sequel of hypertensive disorders of pregnancy and the frequency of IUGR in patients with PIH was found to be 65% [6]. Occurrence of IUGR is notably lower in developed nations, ranging from 4% to 8%, compared to the higher rates observed in developing countries, which range from 6% to 30%. On average, approximately 8% of the general population experiences IUGR [7]. Intrauterine Growth Restriction (IUGR) is classified into symmetrical, asymmetrical, and mixed types. Symmetrical IUGR involves proportional reductions in weight, length, and head circumference, with a head-to-chest circumference difference of less than 3 cm and a Pulsatility Index (PI) greater than 2. It reflects early developmental issues, often linked to genetic factors or early pregnancy complications. Asymmetrical IUGR typically appears in the late second or third trimester due to placental insufficiency, which reduces nutrient supply. While cell numbers remain normal, cell size decreases due to limited glycogen and fat storage. A key marker is a PI less than 2. Mixed IUGR combines characteristics of both symmetrical and asymmetrical IUGR, causing reductions in both cell number and size. This type reflects more complex underlying issues, making diagnosis and management challenging. Understanding the type of IUGR is essential for tailoring prenatal care and improving fetal outcomes through targeted interventions [8]. Maternal, fetal, and placental/adnexal parameters are among the many risk factors for intrauterine growth restriction the primary risk elements are broken down below. Maternal Aspects: A lower socioeconomic status raises the risk of intrauterine growth retard Weight: IUGR may be caused by a very low or exceptionally elevated (BMI). Smoking: it is a major risk factor for IUGR during pregnancy. Recreational Drug Use: Using drugs recreationally while pregnant may harm the development of the fetus. Advanced Maternal Age: the possibility of IUGR is increased for women over 35. Women who become pregnant for the first time are more vulnerable to nulliparity. Overview of Gestational Hypertension: intrauterine growth restriction may result from this condition's limitation in the fetus's blood supply. Family History: The risk gets higher if there is a family history of IUGR or if there have been prior IUGR pregnancies [9]. The prenatal TCD in IUGR babies was less impacted than the fetal HC, indicating that cerebellar growth has been preserved preferentially over other cranial structures. In order to identify aberrant fetal growth, the TCD/AC ratio proved useful. Since this ratio is GA independent, it may be used even when the GA is unclear [10]. Common causes of LBW are restricted intrauterine fetal growth or Intrauterine Growth Retardation (IUGR), Small for Gestational Age (SGA), fetal malnutrition, and preterm birth. Birth weight is one of the predictors for fetal growth, and it is a significant determinant of mortality and morbidity in infancy and childhood. LBW can predict short-term survival and influence the long-term health of the newborn [11]. Fetal biometry, biophysical profile and Doppler studies were found helpful in the diagnosis of intrauterine growth retardation and evaluating the usefulness of ultrasound parameters in third trimester [12]. Previous research has examined the comparison of umbilical artery flow velocimetric indices between IUGR fetuses and normal fetuses in the third trimester.

Current study aimed to detect the frequency and percentage of IUGR pregnancies and normal pregnancies. There is a paucity of research regarding the detection of IUGR frequency during the second and third trimesters. To detect intrauterine growth retardation in 2nd and 3rd trimester with fetal parameters and umbilical artery Doppler.

METHODS

Descriptive cross-sectional study conducted at Diagnostic Centre, Combined Military Hospital, and Lahore from September-December 2024.This study included 2nd and 3rd trimester females. 2nd and 3rd trimester females approaching diagnostic centre for obstetric scan were included in this study and Pregnancies diagnosed with Polyhydromnias during scanning were excluded. Ultrasound of participants was performed using curvilinear transducer (3-5MHz), Toshiba. Sample size was calculated through WHO Geneva calculator.Non probability convenient technique was used.The prevalence of IUGR was found be 90.70% [2].The following Cochran Formula was used to calculate the sample size; $n=\frac{Z^2_{1-\alpha}P(1-P)}{d^2}$ Z value = 1.96 at 95% Confidence level (α), Anticipated population proportion (P) = 0.907, Absolute precision (d) or marginal error = 0.05 and Sample size (n) =130 [13]. Proforma and Ultrasound reports were used as data collection tool. All eligible patients meeting the inclusion criteria were recruited after obtaining informed consent. The ethical considerations of the study were carefully managed, ensuring that the patients were fully aware of the purpose and nature of the study, and their confidentiality and privacy were strictly maintained. A detailed patient history was collected to provide a comprehensive background for analysis.This information was crucial in establishing correlations between patient characteristics and the diagnostic outcomes observed during the study.The examination involved the use of a curvilinear transducer with a frequency range of 3–5 MHz, which is commonly used for obstetric imaging due to its ability to provide detailed images of deep structures. The patients were positioned in a supine position to facilitate optimal imaging.The sonography was performed by either a radiographer or a radiologist. The examination involved both trans-pelvic and Anteroposterior (AP) pelvic planes to maximize the diagnostic information obtained from the ultrasound.

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Cutoff values (2nd-3rd trimester) for confirming IUGR are RI (0.756-0.609), PI (1.270-0.967) and S/D (4-2.18) [14]. Written and verbal consent were taken from eligible participants. The study had been conducted in line with ethical standards set by the ethical review committee of CMH LMC and IOD with (Ref # 80/ERC/CMH/LMC, Dated: 24 September, 2024). This study was conducting in accordance with Declaration of Helsenki. Collected data were entered into the Statistical Package for the Social Sciences (SPSS), version 26.0, for the statistical analysis. The analysis involved both descriptive and inferential statistical methods. For quantitative data, such as gestational age, fetal measurements (e.g., biparietal diameter, femur length, and abdominal circumference), and amniotic fluid index, means and standard deviations were computed to provide a clear understanding of the distribution and variation within the dataset. Frequencies were also calculated. For inferential statistics, Chi-square test was applied to compare the frequencies. A p-value ≤ 0.05 was considered as a statistically significant value.

RESULTS

Current research was on detecting IUGR on ultrasound and umbilical artery doppler. Results of this research have been described below. Summarized key maternal health conditions during pregnancy. Among the females of 2nd and 3rd trimester, 33(25.40%) had a history of intrauterine growth retardation (IUGR). For gestational diabetes, 25(19.2%) were affected. Regarding gestational hypertension, 66(50.8%) experienced it.

Table 1: Prevalence of Maternal Health Conditions N = 130 (100)

Clinical Presentations	Yes Frequency (%)	No Frequency (%)
Previous IUGR History	33 (25.40)	97 (74.60)
Gestational Diabetes	25 (19.2)	105 (80.8)
Gestational Hypertension	66 (50.8)	64 (49.2)

Table 2 showed that during the 2nd trimester, the mean Bi-Parietal Diameter (BPD) on ultrasound was 5.33 cm, with a standard deviation of 0.72 and a median of 5.22 cm (IQR: 5.92–4.82), while in the 3rd trimester, it increased to a mean of 7.96 cm, with a standard deviation of 1.20 and a median of 8.22 cm (IQR: 8.94–7.26).The Head Circumference (HC) increased from a mean of 19.14 cm in the 2nd trimester (SD: 2.50, median: 18.65 cm) to 28.49 cm in the 3rd trimester (SD: 4.09, median: 29.18 cm).Similarly, the Abdominal Circumference (AC) grew from 18.18 cm (SD: 2.75, median: 16.92 cm) to 27.63 cm (SD: 4.21, median: 28.20 cm), and femur length increased from 3.73 cm (SD: 0.62, median: 3.57 cm) to 6.21 cm (SD: 1.15, median: 6.51 cm). Amniotic Fluid Index (AFI) decreased from a mean of 11.86 cm in the 2nd trimester to 7.40 cm in the 3rd trimester.

Table 2: Descriptive Statistics of Fetal Biometric Measurements

Fetal Variables	2nd Trimester		3rd Trimester	
	Median (Inter Quartile range)	Mean ± S.D	Median (Inter Quartile range)	Mean ± S.D
Bi Parietal diameter on Ultrasound (cm)	5.22 (5.92-4.82)	5.33 ± 0.72	8.22 (8.94-7.26)	7.96 ± 1.19
Bi Parietal diameter percentile	2.00 (2.00-2.00)	1.84 ± 0.54	2.00 (2.00-1.00)	1.85 ± 1.37
Head Circumference on Ultrasound (cm)	18.65 (21.14-17.21)	19.13 ± 2.49	29.18 (31.71-25.88)	28.48 ± 4.09
Head Circumference Percentile	2.00 (2.00-2.00)	1.79 ± 0.41	2.00 (2.00-1.00)	27.62 ± 4.21
Abdominal Circumference on Ultrasound (cm)	16.92 (20.62-15.76)	18.18 ± 2.74	28.20 (31.08-25.11)	27.62 ± 4.21
Abdominal Circumference Percentile	2.00 (2.00-2.00)	1.84 ± 0.54	2.00 (2.00-1.00)	1.66 ± 0.97
Femur Length on Ultrasound (cm)	3.57 (4.22-3.26)	3.73 ± 0.62	6.51 (7.09-5.67)	6.20 ± 1.14
Femur Length Percentile	2.00 (2.00-2.00)	1.97 ± 1.24	2.00 (2.00-1.00)	1.62 ± 0.88
Amniotic fluid index in cm	12.00 (14.00-10.00)	11.86 ± 2.03	7.50 (11.00-4.00)	7.39 ± 4.12

Summarized during the 2nd trimester, 25 cases (0.66) showed a discrepancy of less than 14 days, while 13 cases (0.34) had a discrepancy above 14 days. In the 3rd trimester, the number of cases with a discrepancy of less than 14 days increased to 53 (0.58), and those with a discrepancy above 14 days rose to 39 (0.42). Number of total cases above 14 days were 52 in both trimesters resulting in diagnosis of IUGR.

Table 3: Discrepancy in Days across 2nd and 3rd Trimesters

Discrepancy (Days)	2nd Trimester Frequency (%)	3rd Trimester Frequency (%)
Less than 14 Days	25 (0.66)	53 (0.58)
Above 14 Days	13 (0.34)	39 (0.42)
Total	38 (100)	92 (100)

Summarized this data presented the status of Doppler indices across trimesters, comparing normal and abnormal findings. For (RI), 63.2% of cases were normal in the 2nd trimester, compared to 59.8% in the 3rd trimester, with 60.8% normal overall. Abnormal RI cases constituted 36.8% and 40.2% in the 2nd and 3rd trimesters, respectively, with no significant association ($\chi^2 = 0.129$, p =

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0.720). The (PI) showed 63.2% normal cases in the 2nd trimester and 58.7% in the 3rd, totaling 60.0%. Abnormal PI cases were 36.8% and 41.3% in the 2nd and 3rd trimesters, respectively, also showing no significant association (χ^2 = 0.223, p = 0.637). The (S/D ratio) had 63.2% normal findings in the 2nd trimester, 59.8% in the 3rd, and 60.8% overall, with abnormal cases at 36.8% and 40.2%, respectively (χ^2 = 0.129, p = 0.720).

Table 4: Association between Amniotic Fluid Index Status and Trimesters

Variables	Status	Trimester (2nd) Frequency (%)	Trimester (3rd) Frequency (%)	Total Frequency (%)	Chi-Square Value	p-Value
Pulsatility Index Status	Normal	24 (63.2)	54 (58.7)	78 (60.0)	0.223	0.637
	Abnormal	14 (36.8)	38 (41.3)	52 (40.0)		
Resistive Index Status	Normal	24 (63.2)	55 (59.8)	79 (60.8)	0.129	0.720
	Abnormal	14 (36.8)	37 (40.2)	51 (39.2)		
Systolic-to-Diastolic Ratio Status	Normal	24 (63.2)	55 (59.8)	79 (60.8)	0.129	0.720
	Abnormal	14 (36.8)	37 (40.2)	51 (39.2)		

Figure 1 showed third-trimester ultrasound images depicting abnormal umbilical artery Doppler indices and fetal biometry with a 4-week growth lag. Image 1 A displaying the Umbilical artery doppler indices measurements as PI (Pulsatility Index) 0.84, RI (Resistive Index) 0.58 and S/D (Systolic-Diastolic ratio) 2.39. Image 1 B showing fetal measurement as BPD (Bi-Parietal diameter) 7.98cm and HC (Head Circumference) 28.66cm along with discrepancy of 4 weeks between GA (LMP) 35w3d and GA (USG) 31w5d.

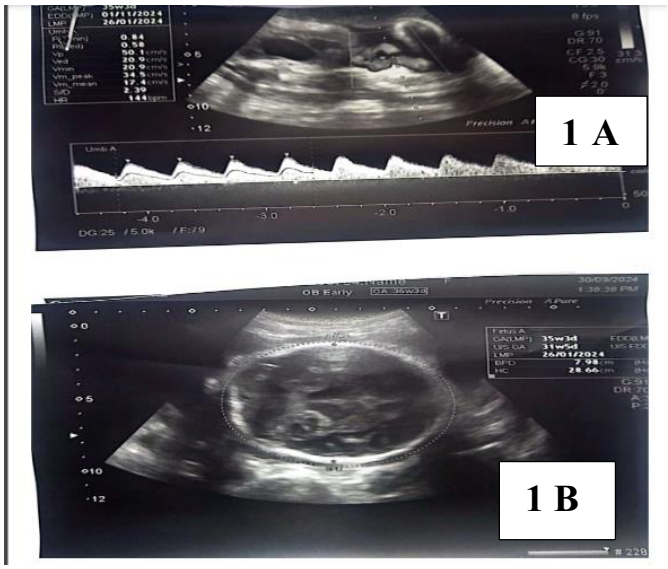

Figure 1: Ultrasound image of female in 3rd trimester

DISCUSSION

Intrauterine Growth Restriction (IUGR) is a condition where a fetus fails to achieve its expected growth potential, often due to placental insufficiency. Ultrasound plays a critical role in diagnosing IUGR by assessing fetal biometry and monitoring amniotic fluid levels. Additionally, umbilical artery Doppler studies provide valuable information about blood flow patterns. Abnormal Doppler findings, such as increased resistance or absent/reversed end-diastolic flow, help guide clinical decisions, including the timing of delivery, to optimize fetal outcomes. Current study examined 130 pregnant females in their 2nd and 3rd trimesters, with 52 cases of IUGR, all of which had abnormal PI values. This study highlighted PI as a reliable diagnostic marker for IUGR. In contrast, the study by Parijatha at Prathima Institute of Medical Sciences analyzed 172 IUGR cases, with 33 showing increased umbilical artery PI [2]. Both studies identified gestational hypertension as a common risk factor, though it was more prevalent in the latter study. While both studies underscore the significance of Doppler indices, particularly PI, for diagnosing IUGR, current study focused more on PI's role compared to other indices like RI and S/D ratios. The study performed by Iftadul Islam at Dhaka medical college. This was study of 90 patients using Doppler ultrasound to assess the cerebral-umbilical pulsatility index ratio found 74.4% of patients had Small for Gestational Age (SGA) babies. Abnormal Doppler values were identified in 72.2% of cases [15]. In contrast, current study analyzed 130 pregnant females, focusing on 52 IUGR cases, where abnormal PI values were strongly associated with IUGR. It was observed that discrepancies in fetal growth of 15 to 43 days (3-6 weeks), indicated significant differences between expected and actual gestational age. Both studies highlighted the critical role of Doppler ultrasound in diagnosing IUGR and its impact on predicting fetal outcomes. While the other study emphasized the cerebral-umbilical pulsatility index ratio and premature delivery, current study pointed out the relationship between abnormal PI values and IUGR diagnosis, with growth discrepancies suggesting delayed fetal development. Current study, analyzed 130 pregnant females in their 2nd and 3rd trimesters, found IUGR in 52 cases, with discrepancies ranging from 15 to 43 days (3-6 weeks). A history of gestational hypertension was seen in 50.8%, and gestational diabetes in 19.2%. In contrast, a study by Farrah Shams at DOW university, Karahi Pakistan focused on hypertensive and diabetic groups reported a 46% rate of fetal distress in hypertensive patients and 10% Intrauterine Death (IUD) in diabetic pregnancies and IUGR was seen 6% with hypertension. Ultrasound scans showed 68% in hypertensive, and 54% in diabetic groups [16]. Both studies highlighted the risks associated with hypertension and

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diabetes in pregnancy, but current study specifically emphasized the role of Doppler PI values as a key marker in diagnosing IUGR. The larger study by Zhou, China included 6,105 women identified several key risk factors, included maternal age under 25, prim parity, low BMI, insufficient weight gain, and pregnancy-induced hypertension. It found that 8.65% of pregnancies were complicated by IUGR [17]. In contrast, current study analyzed 130 pregnant females, with IUGR observed in 52 cases, and emphasized the role of Doppler ultrasound.Current findings highlighted gestational hypertension as a prominent factor (observed in 50.8% of cases) and found abnormal Pulsatility Index (PI) values to be a more reliable indicator of IUGR than Resistance Index (RI) or S/D ratios. Both studies underscored the importance of maternal health factors in IUGR, though current study specifically focused on Doppler findings, which correlate closely with IUGR diagnosis. The first study by Mandana Mansour Ghanaei at Alzahra University, Iran involved 216 cases, divided IUGR into two groups: those with preeclampsia (PE-IUGR) and those without preeclampsia (I-IUGR).It found that chronic hypertension was significantly more prevalent in the PE-IUGR group (95.4%) compared to the I-IUGR group (4.6%). The study also highlighted a significant difference in gestational age at birth, with the PE-IUGR group delivered earlier [18]. In contrast, current study, which analysed 130 pregnancies, emphasized the use of Doppler ultrasound to identify abnormal Pulsatility Index (PI) values as a reliable diagnostic indicator for IUGR. It also revealed that 50.8% of cases had gestational hypertension.Both studies highlighted hypertension as a significant risk factor for IUGR, but current study focused more on Doppler indices, particularly PI, for IUGR diagnosis, while the first study looked at the impact of preeclampsia and its association with earlier delivery. Study performed by Kiran *et al.*, directly examined placental tissues and found significantly lower placental weights, increased syncytial knots, and fewer blood vessels in the villi of IUGR cases compared to normal pregnancies [19]. Similarly, the current study demonstrated that abnormal Pulsatility Index (PI) values were strongly associated with IUGR, along with discrepancies in fetal growth ranging from 15 to 43 days, suggesting impaired placental blood flow. However, the studies differ in their methodology and focus: Kiran et al., used a histopathological approach, examining structural differences in the placenta post-delivery, while the current study used clinical diagnostic tools, such as Doppler ultrasound, to assess functional changes during pregnancy [19]. Thus, while both studies support the link between placental insufficiency and IUGR, they approach the issue from different investigative perspectives one anatomical, the other hemodynamic. Study by Qahtani underscores the clinical value of accurate identification to reduce the risks of stillbirth, neonatal morbidity and mortality, and to prevent unnecessary interventions in unaffected pregnancies. The study strongly advocates for the use of Doppler velocimetry of both fetal venous and arterial circulation as a key surveillance tool in managing fetal growth restriction [20]. Similarly, the current study supports this diagnostic approach by analyzing 130 pregnant women, including 52 confirmed IUGR cases, and finding a strong correlation between abnormal Pulsatility Index (PI) values and IUGR. Furthermore, it highlighted significant fetal growth discrepancies, ranging from 15 to 43 days, between expected and actual gestational age reinforcing the importance of Doppler findings in identifying and monitoring IUGR cases. While Qahtani's study provides a theoretical and clinical framework, the current study offers empirical evidence supporting the use of Doppler as a practical diagnostic measure in real-world clinical settings. Factors like the mothers' health conditions, diet, and financial situation weren't considered. These could have affected the rates of IUGR and the Doppler results. The study didn't track what happened to the babies after birth, which could have given more insight into how IUGR and Doppler changes impact their health. Potential confounding factors weren't controlled during data collection and analysis.

CONCLUSIONS

In conclusion, fetal biometric parameters (BPD, HC, AC, FL) below the 10th percentile indicated IUGR in over one-third of 2nd and 3rd trimester pregnancies, with growth lags of 15-43 days. Abnormal umbilical artery Doppler PI was present in all IUGR cases, highlighting PI as a consistent and reliable detection marker.

Authors Contribution

Conceptualization: ZS
Methodology: ZS
Formal analysis: AR
Writing, review and editing: SS, KTK, YK, AR, AA

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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REFERENCES

[1] Abbas G, Shah S, Hanif M, Shah A, Rehman AU, Tahir S *et al.* The frequency of pulmonary hypertension in newborn with intrauterine growth restriction. Scientific Reports.2020May;10(1):8064.doi:10.1038/s41598-020-65065-2.

[2] Parijatha T, Rao PS, Bharathi PK. Role of doppler ultrasonography in prediction of adverse perinatal outcome in intrauterine growth retardation (IUGR). International Archives of Integrated Medicine.2022 Feb;9(2).

DOI: https://doi.org/10.54393/pjhs.v6i6.3012

[3] Yadav SS, Singh A, Yadav K. A prospective study to evaluate the role of routine early third trimester ultrasound in the diagnosis of intrauterine growth restriction and prediction of adverse perinatal outcome using color Doppler. International Journal Reproduction Contraception Obstetrics and Gynecology.2020Nov;9(11):4506-13.doi:10.18203/2320-1770.ijrcog20204801.

[4] Nnamani AO, Ibewuike CU, Okere PC, Obikili EN. Comparative analysis of umbilical artery doppler indices of normal and suspected IUGR fetuses in the third trimester. Nigerian Journal of Clinical Practice. 2021Dec;24(12):1793-9.doi:10.4103/njcp.njcp_46_18.

[5] Shrivastava D and Master A. Fetal Growth Restriction. The Journal of Obstetrics and Gynecology of India. 2020 Apr; 70(2): 103-10. doi:10.1007/s13224-019-01278-4.

[6] Aftab S, Ayaz S, Hussain SF, Hussain AS. Frequency and outcome of Intrauterine Growth Restriction (IUGR) in pregnancy induced hypertension.Pakistan Journal of Surgery.2022Jul;38(3).doi:10.54393/pjhs.v4i09.1019.

[7] Khanduri S, 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.2017Nov; 9(11): e1827. doi: 10.7759/cureus.1827.

[8] Murki S and Sharma D. Intrauterine growth retardation-a review article. Journal of Neonatal Biology.2014;3(3):1-1.doi:10.4172/2167-0897.1000135.

[9] Albu AR, Anca AF, Horhoianu VV, Horhoianu IA. Predictive factors for intrauterine growth restriction. Journal of Medicine and Life. 2014 Jun; 7(2): 165.

[10] El-Aal HM, Ellaban MM, Omran ME. Ultrasound Assessment of Fetal Transcerebellar Diameter to Abdominal Circumference Ratio (Tcd/Ac) and to Femur Length Ratio (Tcd/Fl) in Detection of IUGR.Al-Azhar International Medical Journal.2023;4(6):13. doi: 10.58675/2682-339X.1851.

[11] Samsury SF, Ismail TA, Hassan R. Low birth weight infant among teenage pregnancy in Terengganu, Malaysia: A cross-sectional study. Malaysian Family Physician: the Official Journal of the Academy of Family Physicians of Malaysia. 2022 Mar; 17(1): 44. doi: 10.51866/oa.59.

[12] Naeem MA, Rauf H, Aftab SK, Mahrukh F, John A, Kiran W. Prevalence of Intrauterine Growth Retardation on Antenatal Ultrasound Scan in Lahore, Pakistan. Lahore Garrison University Journal of Life Sciences.2022Nov;6(04):350-9.doi:10.54692/lgujls.2022.0604234.

[13] Nanjundeswaraswamy TS and Divakar S. Determination of sample size and sampling methods in applied research.Proceedings on Engineering Sciences.2021Mar;3(1):25-32.doi:10.24874/PES03.01.003.

[14] Campos A KH and Murphy A. Umbilical arterial Doppler assessment Reference article, Radiopaedia.org 2024.2025 Jan. doi: 10.53347/rID-13860.

[15] Islam I, Yasmin T, Rubaiat L, Arephin SS, Hossain MM, Asfia A. Color Doppler Imaging of Cerebral-Umbilical Pulsatility Ratio in Intrauterine Growth Retardation. Journal of Enam Medical College.2017Oct;7(3):140-5.doi: 10.3329/jemc.v7i3.34073.

[16] Shams F, Ali F, Samoo N, Malik F, Asif U, Gul A *et al.* To Associate the Fetal Distress, IUD and IUGR Observed in Normal, Diabetic and Hypertensive Pregnancies. Pakistan Biomedical Journal.2022Jan:212-5.doi:10.54393/pbmj.v5i1.256.

[17] Li Y, Zhou S, Wang X, He Y, Shen L, Huang X *et al.* Study on the determinants of intrauterine growth restriction. Zhonghua liu Xing Bing xue za zhi= Zhonghua Liuxingbingxue Zazhi.2015Aug;36(8):807-10.

[18] Mansour Ghanaei M, Amir Afzali S, Morady A, Mansour Ghanaie R, Asghari Ghalebin SM, Rafiei E *et al.* Intrauterine growth restriction with and without pre-eclampsia: pregnancy outcome and placental findings. Journal of Obstetrics, Gynecology and Cancer Research.2022Jan;7(3):177-85.doi:10.30699/jogcr.7.3.177.

[19] Kiran N, Aslam N, Tabassum T, Kanwal S, Zia T. Morphological findings in intrauterine growth restriction (IUGR) placentas versus normal placentas in pregnant women of district Rawalpindi, Pakistan. Gomal Journal of Medical Sciences.019Sep;17(3):65-9. doi: 10.46903/gjms/17.03.2021.

[20] Qahtani NA. Doppler ultrasound in the assessment of suspected intra-uterine growth restriction.Annals of African Medicine.2011Oct;10(4):266-71.doi:10.4103/1596-3519.8704