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ROLE OF UTERINE ARTERY DOPPLER INDICES IN PREDICTING INTRAUTERINE GROWTH RESTRICTION IN PRE-ECLAMPTIC WOMEN

Original Research

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ABSTRACT

Background: Intrauterine growth restriction (IUGR) is a significant complication of pregnancy, contributing to increased perinatal morbidity and mortality worldwide. It often arises from placental insufficiency, which impairs fetal development, particularly in pregnancies complicated by preeclampsia. Early detection of IUGR is essential to prevent adverse outcomes, and Doppler ultrasonography, specifically the uterine artery resistance index (RI), has emerged as a valuable non-invasive tool for monitoring high-risk pregnancies.

Objective: To evaluate the diagnostic accuracy of the uterine artery resistance index in predicting intrauterine growth restriction among pregnant women diagnosed with preeclampsia.

Methods: A cross-sectional study was conducted from January 17, 2022, to June 16, 2024, in the Radiology Department of the University of Lahore Teaching Hospital, Lahore. Ethical approval was granted by the hospital's ethics committee. A total of 334 pregnant women in their third trimester with clinically diagnosed preeclampsia were referred for Doppler ultrasonography to assess uteroplacental circulation. Uterine artery resistance indices were measured using a SIEMENS Sonoline Doppler ultrasound system by a certified radiologist. Data were analyzed using SPSS version 2.0. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated using birth weight as the gold standard.

Results: Of the 334 participants, 155 (46.4%) were predicted to have IUGR based on elevated uterine artery RI, while 179 (53.6%) were not. At birth, IUGR was confirmed in 176 (52.7%) neonates. The mean uterine artery RI was 0.52 ± 0.08. The sensitivity and specificity of the uterine artery RI were 76.7% and 87.3%, respectively. The PPV was 87.1%, while the NPV was 77.1%. The overall diagnostic accuracy was 81.7%.

Conclusion: The uterine artery resistance index is a reliable predictor of intrauterine growth restriction in preeclamptic pregnancies. Doppler ultrasonography offers a valuable, non-invasive tool for early detection, enabling timely interventions and improving fetal outcomes.

Keywords: Doppler ultrasonography, fetal growth restriction, preeclampsia, pregnancy complications, prenatal diagnosis, uterine artery resistance index, uteroplacental insufficiency

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INTRODUCTION

Intrauterine growth restriction (IUGR) remains a significant concern in obstetrics, affecting an estimated 10–15% of pregnancies globally. This condition, often undiagnosed during gestation, is frequently identified only after birth, posing substantial risks of neonatal morbidity and mortality (1). While IUGR itself is not a distinct disease, it represents a clinical manifestation of various maternal and fetal disorders. Accurately identifying the underlying cause is essential for guiding management, improving prognosis, and providing appropriate counseling, especially considering the strong association of IUGR with congenital malformations and chromosomal abnormalities (2). Among the primary factors implicated in the development of IUGR is placental insufficiency, which arises from suboptimal trophoblastic invasion of the maternal spiral arteries. This abnormal vascular remodeling increases uteroplacental resistance, reduces perfusion, and subsequently impairs fetal growth (3). Preeclampsia, characterized by heightened vascular resistance and placental insufficiency, is a major contributor to IUGR. Early identification of placental dysfunction in preeclamptic pregnancies is vital to minimizing adverse fetal outcomes through timely interventions (3). Doppler ultrasonography has emerged as a valuable non-invasive diagnostic tool in high-risk pregnancies, capable of detecting hemodynamic changes associated with hypoxia before clinical deterioration is evident on other monitoring modalities (4,5). Specifically, Doppler analysis of uterine artery flow patterns offers crucial insight into uteroplacental perfusion. Abnormal findings, such as elevated resistance indices or the presence of an early diastolic notch, are strong predictors of adverse pregnancy outcomes and poor fetal growth (6).

In cases of preeclampsia, impaired trophoblast invasion results in persistent high-resistance uterine artery flow, contributing to progressive placental ischemia as gestation advances (7). Clinically, this manifests as elevated risks for complications including placental abruption, stillbirth, preterm delivery, and severe maternal morbidity such as cerebral hemorrhage, renal failure, or hepatic dysfunction if left unmanaged (8). Normal physiological adaptations during pregnancy involve a decline in uteroplacental resistance and increased blood flow, changes that are notably absent in preeclamptic women (9,10). Consequently, performing uterine artery Doppler assessments between 20–24 weeks of gestation in women at high risk of preeclampsia has been recommended for early detection of impaired perfusion (11-13). Persistent abnormalities in uterine artery Doppler readings, such as elevated resistance index (RI), pulsatility index (PI), or systolic/diastolic (S/D) ratios, alongside the presence of a diastolic notch, signal compromised fetoplacental circulation and are associated with an increased likelihood of IUGR (14,15). Early identification of such Doppler abnormalities enables clinicians to implement timely interventions, improving fetal outcomes and reducing the risks of perinatal complications (13). This study aims to investigate the predictive role of uterine artery Doppler indices in identifying intrauterine growth restriction among preeclamptic women. By evaluating specific Doppler parameters, the research seeks to establish whether early detection of abnormal uteroplacental flow can serve as a reliable predictor of fetal growth impairment, ultimately facilitating timely interventions to enhance maternal and fetal health outcomes.

METHODS

A cross-sectional study was conducted in the Radiology Department of the University of Lahore Teaching Hospital, Lahore, spanning from January 17, 2022, to June 16, 2024. Ethical approval for this research was granted by the hospital's ethics committee. Informed consent was obtained from all participants before inclusion in the study, ensuring adherence to ethical standards for human research. The study included 334 pregnant women diagnosed with preeclampsia by an obstetrician, all of whom were referred to the Radiology Department for Doppler ultrasonography to assess uteroplacental circulation during their third trimester. Inclusion criteria were limited to pregnant women with confirmed preeclampsia in their third trimester. Exclusion criteria involved factors that could potentially confound the results, such as preterm labor, premature rupture of membranes, multiple gestations, fetal anatomical abnormalities, and gestational diabetes. These exclusions were necessary to minimize the influence of other factors that could independently affect fetal growth and the uteroplacental circulation, ensuring the validity of the study findings.

Each participant underwent Doppler ultrasonography performed by a single radiologist, a fellow of the College of Physicians and Surgeons Pakistan (CPSP), to ensure consistency in imaging and measurement techniques. A SIEMENS Sonoline ultrasound machine equipped with Doppler imaging capabilities was used for all assessments. Patients were positioned in a semi-recumbent posture, and the ultrasound probe was placed over the abdominal iliac fossae. A sagittal view of the cervical canal and uterus was obtained, and color

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Doppler flow was applied until the uterine artery was visualized crossing the external iliac artery. Pulsed-wave Doppler was then employed to measure the resistance index (RI) of the uterine artery, an indicator of blood flow resistance within the uteroplacental circulation. Data were systematically recorded and analyzed using SPSS version 2.0. For categorical variables, such as the presence or absence of intrauterine growth restriction (IUGR), frequencies and percentages were calculated. Numerical variables, including maternal age, birth weight, and uterine artery RI, were presented as mean values with standard deviations (mean ± SD) to describe central tendencies and dispersion. Birth weight was used as the gold standard for determining the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of uterine artery Doppler indices in predicting IUGR. A contingency table was constructed to facilitate the calculation of these diagnostic accuracy measures.

RESULTS

The study included 334 pregnant women with preeclampsia, with a mean age of 30.14 ± 8.36 years, ranging from 21 to 45 years. Based on the uterine artery resistance index (RI), 155 participants (46.4%) were predicted to have intrauterine growth restriction (IUGR), while 179 participants (53.6%) showed no signs of IUGR according to Doppler findings. At birth, 176 infants (52.7%) were confirmed to have IUGR, whereas 158 infants (47.3%) had normal growth outcomes. The average uterine artery RI across all participants was recorded at 0.52 ± 0.08, and abnormal Doppler waveforms indicating high-resistance flow were observed in cases with impaired uteroplacental circulation. The mean birth weight for all neonates was 2880 ± 501 grams. When stratified by age, the distribution of predicted IUGR cases revealed a trend of increasing prevalence with advancing maternal age. In the age group of 20–25 years, 44 individuals were predicted to have IUGR. Among those aged 26–30 years, 36 cases of predicted IUGR were observed. Similarly, 36 participants aged 31–35 years were also expected to have growth restriction. In older age groups, 25 participants aged 36–40 years and 14 participants aged 41–45 years showed evidence of IUGR, indicating a higher risk of fetal growth restriction as maternal age increased.

Diagnostic evaluation revealed that 135 out of the 155 patients (87.1%) with abnormal uterine artery RI had confirmed IUGR at birth, whereas 20 patients (12.9%) showed no evidence of growth restriction despite elevated RI. In contrast, among the 179 participants with normal uterine artery RI, 41 patients (22.9%) experienced IUGR, while 138 patients (77.0%) had normal fetal growth. Using birth weight as the gold standard, the sensitivity of the uterine artery RI in predicting IUGR was 76.7%, with a specificity of 87.3%. The positive predictive value (PPV) was 87.1%, while the negative predictive value (NPV) was 77.1%. Overall, the diagnostic accuracy of the uterine artery resistance index in predicting IUGR was calculated to be 81.7%.

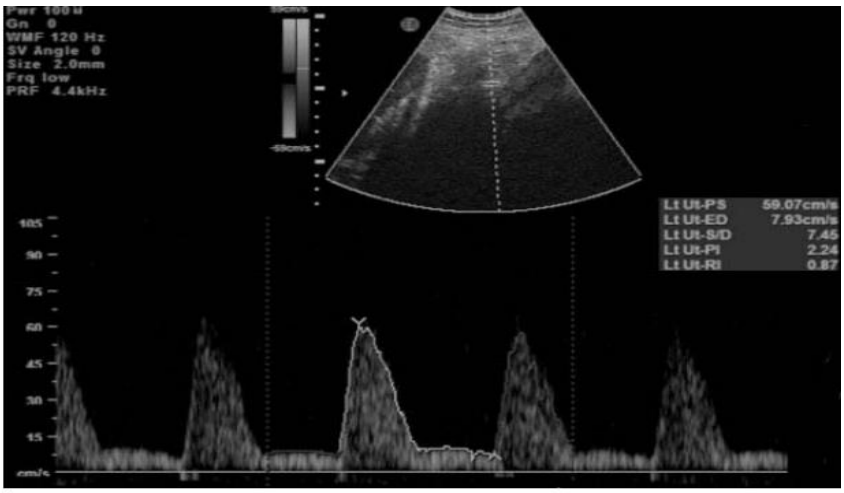

Fig 1: High Resistance Flow in Uterine Artery

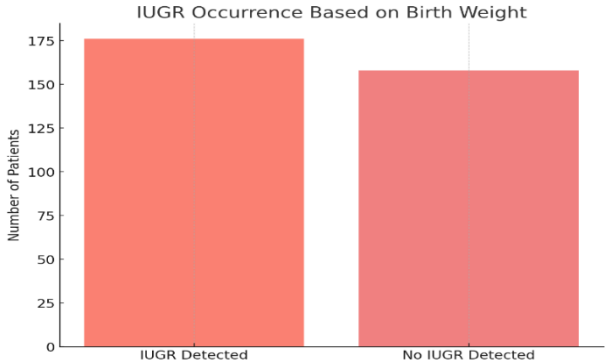

Figure 1 IUGR Occurrence Based on Birth Weight

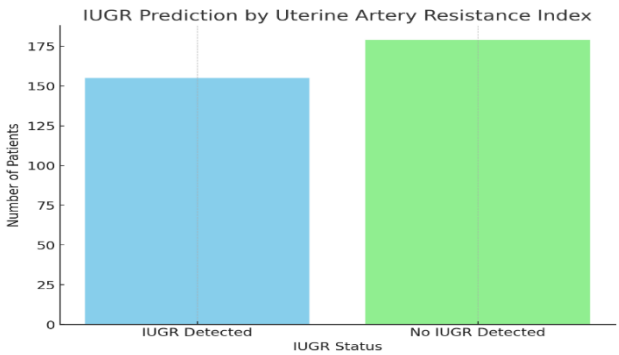

Figure 2 IUGR Prediction by Uterine Artery Resistance index

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Table 1: Diagnostic variables with respect to birth weight (n=334)

			IUGR with Birth weight		
			Yes	No	**Total**
Abnormal Uterine artery with RI	Yes	**Patient No.**	**135(a)**	**20(b)**	**155**
		IUGR %age with Uterine artery RI	87.1%	12.9%	100%
		IUGR %age with Birth weight	76.7%	12.7%	46.4%
	No	**Patient No.**	**41(c)**	**138(d)**	**179**
		IUGR %age with Uterine artery RI	22.9%	77.0%	100%
		IUGR %age with Birth weight	23.3%	87.3%	53.6%
	Total	**Patient No.**	**176(52.7%)**	**158(47.3%)**	**334(100%)**

DISCUSSION

Fetal growth restriction (FGR) is a significant contributor to perinatal morbidity and long-term developmental impairments, underscoring the need for accurate identification of at-risk fetuses. A fetus is typically classified as having intrauterine growth restriction (IUGR) when its birth weight and/or length fall below the 10th percentile for its gestational age (14-16). The current study aimed to evaluate the predictive capacity of the uterine artery resistance index (RI) in identifying IUGR among pregnant women diagnosed with preeclampsia. The findings demonstrated that a resistance index exceeding 0.53 was indicative of abnormal uteroplacental circulation. Based on this parameter, IUGR was anticipated in 46.4% of participants, while 52.7% of neonates were confirmed to have growth restriction at birth (17). The diagnostic performance of the uterine artery RI revealed a sensitivity of 76.7% and specificity of 87.3%, with a positive predictive value (PPV) of 87.1% and a negative predictive value (NPV) of 77.1%. These results suggest a high level of accuracy (81.7%) in predicting fetal growth restriction using uterine artery Doppler measurements. When compared to existing literature, the sensitivity and PPV reported in the current study were slightly lower than those observed in similar research, which reported sensitivity and PPV values of 84.6% and 90.2%, respectively. However, the specificity and NPV in this study were higher than those previously reported, indicating better performance in correctly identifying non-IUGR cases (18-20).

Contrasting findings from other studies reveal varied diagnostic efficiencies for the uterine artery resistance index. While some research has demonstrated specificity and NPV values reaching up to 97%, sensitivity and PPV remained lower, suggesting a disparity in the ability of the Doppler technique to consistently predict all cases of IUGR. This variation could be attributed to differences in study design, population characteristics, or operator-dependent factors inherent to Doppler ultrasonography. Additionally, research reporting lower sensitivity and PPV, with values as low as 57% and 23.5%, respectively, highlights the limitations of relying solely on uterine artery Doppler indices for IUGR prediction (21-23). The strengths of this study include the use of a standardized protocol for Doppler measurements, performed by a single experienced radiologist, which minimized inter-observer variability. The sample size was substantial, improving the reliability and generalizability of the findings within similar clinical settings. Moreover, the exclusion of confounding factors such as multiple gestations, gestational diabetes, and fetal anomalies allowed for a clearer assessment of the relationship between preeclampsia and IUGR (24).

However, several limitations must be acknowledged. The reliance on a single operator, while reducing variability, could introduce systematic bias, potentially affecting the reproducibility of results in a broader clinical context. Additionally, the use of birth weight as the sole gold standard for IUGR diagnosis may overlook cases of asymmetrical growth restriction or subtle growth abnormalities that could have been detected using other parameters, such as customized growth charts or serial fetal biometry. The lack of longitudinal follow-up data also prevents the assessment of long-term outcomes in neonates affected by IUGR (25). Future research should consider multicenter studies with larger, more diverse populations to validate the findings across various healthcare settings. Incorporating additional Doppler indices, such as those from the umbilical artery or middle cerebral artery, alongside uterine artery measurements, could enhance the predictive accuracy for IUGR. Furthermore, integrating biochemical markers with Doppler ultrasound may provide

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a more comprehensive risk assessment for fetal growth restriction in preeclamptic pregnancies (26-28). The uterine artery resistance index demonstrates strong diagnostic performance in predicting IUGR among preeclamptic women, with high specificity and PPV. Despite its limitations, uterine artery Doppler ultrasonography remains a valuable non-invasive tool for identifying high-risk pregnancies and facilitating timely clinical interventions to mitigate adverse perinatal outcomes.

CONCLUSION

Preeclampsia is strongly associated with intrauterine growth restriction (IUGR), a leading cause of perinatal morbidity and mortality. This study highlights the significance of Doppler ultrasonography, particularly the measurement of the uterine artery resistance index, as a vital tool for monitoring high-risk pregnancies. Early detection of impaired uteroplacental circulation enables timely interventions, ensuring appropriate management and hospital delivery when necessary. By facilitating prompt care for preeclamptic women, this approach can significantly improve fetal outcomes and reduce complications associated with growth restriction, underscoring the importance of incorporating Doppler assessments into routine prenatal evaluations for at-risk pregnancies.

AUTHOR CONTRIBUTIONS

Author	Contribution
Muhammad Ahmad Raza*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Riffat Bibi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Abdullah Zaka	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Shafqat Rehman	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Syeda Kiran Aftab	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Raheel Abrar	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

REFERENCES

1. Adefisan AS, Akintayo AA, Awoleke JO, Awolowo AT, Aduloju OP. Role of second-trimester uterine artery Doppler indices in the prediction of adverse pregnancy outcomes in a low-risk population. Int J Gynaecol Obstet. 2020;151(2):209-13.

2. Bertholdt C, Hossu G, Banasiak C, Beaumont M, Morel O. First trimester screening for pre-eclampsia and intrauterine growth restriction using three-dimensional Doppler angiography (SPIRIT): protocol for a multicentre prospective study in nulliparous pregnant women. BMJ Open. 2020;10(10):e037751.

3. Lane SL, Doyle AS, Bales ES, Lorca RA, Julian CG, Moore LG. Increased uterine artery blood flow in hypoxic murine pregnancy is not sufficient to prevent fetal growth restriction†. Biol Reprod. 2020;102(3):660-70.

4. Običan SG, Odibo L, Tuuli MG, Rodriguez A, Odibo AO. Third trimester uterine artery Doppler indices as predictors of preeclampsia and neonatal small for gestational age. J Matern Fetal Neonatal Med. 2020;33(20):3484-9.

5. Okido MM, Bettiol H, Barbieri MA, Marcolin AC, Quintana SM, Cardoso VC, et al. Can increased resistance to uterine artery flow be a risk factor for adverse neurodevelopmental outcomes in childhood? A prospective cohort study. J Obstet Gynaecol. 2020;40(6):784-91.

6. Tapp S, Guerby P, Girard M, Roberge S, Côté S, Ferreira E, et al. A Pilot Randomized Trial Comparing the Effects of 80 versus 160 mg of Aspirin on Midtrimester Uterine Artery Pulsatility Index in Women with a History of Preeclampsia. J Obstet Gynaecol Can. 2020;42(12):1498-504.

7. Tosun G, Kose S, İşbilen Başok B, Altunyurt S. First-trimester placental function in levothyroxine-using pregnant women: a case-control study. Gynecol Endocrinol. 2020;36(3):233-7.

8. Faber R, Heling KS, Steiner H, Gembruch U. Doppler ultrasound in pregnancy - quality requirements of DEGUM and clinical application (part 2). Ultraschall Med. 2021;42(5):541-50.

9. Jurisic A, Jurisic Z, Lefkou E, Girardi G. Pravastatin plus L-arginine prevents adverse pregnancy outcomes in women with uteroplacental vascular dysfunction. Vascul Pharmacol. 2021;137:106824.

10. Meler E, Martínez J, Boada D, Mazarico E, Figueras F. Doppler studies of placental function. Placenta. 2021;108:91-6.

11. Molina Pérez CJ, Nolasco Leaños AG, Carrillo Juárez RI, Berumen Lechuga MG, Isordia Salas I, Leaños Miranda A. Soluble Endoglin and Uterine Artery Flow Doppler Ultrasonography as Markers of Progression to Preeclampsia in Women with Gestational Hypertension. Gynecol Obstet Invest. 2021;86(5):445-53.

12. Paules C, Miranda J, Policiano C, Crovetto F, Youssef L, Hahner N, et al. Fetal neurosonography detects differences in cortical development and corpus callosum in late-onset small fetuses. Ultrasound Obstet Gynecol. 2021;58(1):42-7.

13. Wu JN, Ren YY, Zhu C, Peng T, Zhang B, Li MQ. Abnormal placental perfusion and the risk of stillbirth: a hospital-based retrospective cohort study. BMC Pregnancy Childbirth. 2021;21(1):308.

14. Abdel Azim S, Wright A, Sapantzoglou I, Nicolaides KH, Charakida M. Ophthalmic artery Doppler at 19-23 weeks' gestation in pregnancies that deliver small-for-gestational-age neonates. Ultrasound Obstet Gynecol. 2022;60(1):52-8.

15. Canto MJ, Ortiz-Santamaria V, Palau J, Cuquet J, Ojeda F. Value of second-trimester uterine artery pulsatility index in pregnancies with systemic lupus erythematosus and/or antiphospholipid syndrome. J Matern Fetal Neonatal Med. 2022;35(25):6586-92.

16. Chen JY, Chen M, Wu XJ, Sun JM, Zhang Y, Li YF, et al. The value of placental vascularization indices for predicting preeclampsia and fetal growth restriction in different stages of gestation: A prospective and longitudinal study. Placenta. 2022;122:1-8.

17. Nowacka U, Papastefanou I, Bouariu A, Syngelaki A, Akolekar R, Nicolaides KH. Second-trimester contingent screening for small-for-gestational-age neonate. Ultrasound Obstet Gynecol. 2022;59(2):177-84.

18. Stevens D, Schiffer V, Severens-Rijvers C, de Nobrega Teixeira J, van Haren A, Spaanderman M, et al. The association between decidual vasculopathy and abnormal uterine artery Doppler measurement. Acta Obstet Gynecol Scand. 2022;101(8):910-6.

19. Zhou P, Sun Y, Tan Y, An Y, Wang X, Wang L. Fetal and Neonatal Middle Cerebral Artery Hemodynamic Changes and Significance under Ultrasound Detection in Hypertensive Disorder Complicating Pregnancy Patients with Different Severities. Comput Math Methods Med. 2022;2022:6110228.

20. Jie M, Jaufuraully S, Lambert J, Napolitano R, Siassakos D. Second trimester abnormal uterine artery Dopplers and adverse obstetric and neonatal outcomes when PAPP-a is normal. J Matern Fetal Neonatal Med. 2023;36(2):2230515.

21. Kale RM, Tirupathi RG, Sheela SR. Role of Ultrasonography and Color Doppler in the Assessment of High-Risk Pregnancies and Their Accuracy in Predicting Fetal Outcome. Cureus. 2023;15(5):e39017.

22. Meroni A, Mascherpa M, Minopoli M, Lambton B, Elkalaawy R, Frick A, et al. Is mid-gestational uterine artery Doppler still useful in a setting with routine first-trimester pre-eclampsia screening? A cohort study. Bjog. 2023;130(9):1128-34.

23. Mula R, Prats P, García S, Serra B, Scazzocchio E, Meler E. Angiogenic factors assessment in pre-eclampsia high-risk population for the prediction of small-for-gestational age neonates: A prospective longitudinal study. Int J Gynaecol Obstet. 2023;161(2):439-46.

24. Hong J, Crawford K, Cavanagh E, da Silva Costa F, Kumar S. Placental growth factor and fetoplacental Doppler indices in combination predict preterm birth reliably in pregnancies complicated by fetal growth restriction. Ultrasound Obstet Gynecol. 2024;63(5):635-43.

25. Johannesson L, Testa G, Borries TM, Wall A, Ma TW, Eagle EA, et al. Doppler Flow Indices and Prediction of Embryo Transfer Success and Pregnancy Outcome in Uterus Transplant Recipients. Am J Perinatol. 2024;41(S 01):e1264-e72.

26. Wartelle T, Ray CL, Cohen E, Torchin H, Goffinet F. Prognosis for fetuses with isolated severe growth retardation from 23 gestational weeks with an initial assessment unfavorable to an active management. J Gynecol Obstet Hum Reprod. 2025;54(3):102905.

27. Malik M, Maqbool M, Nisar T, Akhter T, Ujan JA, Algarni AS, Al Joufi FA, Alanazi SS, Almotared MH, Bekhit MM, Jamil M. Deciphering key genes involved in cisplatin resistance in kidney renal clear cell carcinoma through a combined in silico and in vitro approach. Oncology Research. 2023 Sep 15;31(6):899–916. doi: 10.32604/or.2023.030760.

28. Amin, Nasira, Shah Room, Sher Alam Khan, Sudhair Abbas Bangash, Ambreen Nasir, and Abdul Sami Shaikh. “Association Between Maternal Thyroid Function and Pregnancy Outcomes: A Clinical Analysis.” Insights-Journal of Health and Rehabilitation 2, no. 2 (2024). https://doi.org/10.71000/gyymy725.

