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Role of Color Doppler Velocimetry in Diagnosing Intrauterine Growth Restriction and Predicting Adverse Perinatal Outcomes

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HIGHLIGHTS

1. Color Doppler aids early IUGR detection
2. Umbilical artery changes indicate fetaldistress
3. Middle cerebral artery shows brain sparing
4. Abnormal Doppler linked to poor outcomes
5. High-risk pregnancies benefit from Doppler
6. Doppler predicts neonatal ICU admissions
7. Effective tool for fetal growth monitoring

Key words:
Intrauterine growth restriction
Doppler velocimetry
Placental insufficiency
Fetal circulation
Umbilical artery

ABSTRACT

Introduction: Intrauterine Growth Restriction (IUGR) is a condition where the fetus does not reach its expected growth potential, commonly resulting from placental insufficiency, maternal hypertension, diabetes, or lifestyle factors. Accurate diagnosis and timely management are essential to prevent adverse perinatal outcomes. Doppler velocimetry is an invaluable tool for assessing fetal circulation and placental function in pregnancies at risk of IUGR. **Aim and Objective:** The study aims to evaluate the role of color Doppler indices in diagnosing IUGR, focusing on the utility of Doppler velocimetry of the umbilical artery (UA), middle cerebral artery (MCA), and ductus venosus in high-risk singleton pregnancies. **Materials and Methods:** A single-centric, prospective, observational, cross-sectional study was conducted at the Department of Radiology, Sri Siddhartha Medical College Hospital and Research Centre, Tumkur, over 24 months. A total of 100 high-risk pregnant women with suspected IUGR were included based on ultrasound findings of estimated fetal weight and abdominal circumference below the 10th percentile. Color Doppler indices were analyzed, and data were statistically compared to assess their predictive value. **Results:** The majority of cases (39%) were between 31–35 weeks of gestation. Elevated umbilical artery pulsatility index (67%) and abnormal uterine artery flow (74%) were observed, with an abnormal MCA/UA PI ratio (<1.08) in 65%, indicating brain-sparing physiology. Doppler indices, especially UA PI and MCA/UA PI, showed high sensitivity in predicting adverse perinatal outcomes. Conclusion: Doppler velocimetry is a reliable diagnostic tool for identifying IUGR and guiding obstetric management. The study underscores the importance of integrating Doppler assessments into routine antenatal screening for high-risk pregnancies to ensure early intervention and improve fetal outcomes.

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INTRODUCTION

Intrauterine Growth Restriction (IUGR) is a condition where the fetus does not achieve its anticipated growth potential during pregnancy, leading to a smaller size than expected for its gestational age. It is diagnosed when the estimated fetal weight is below the 10th percentile for the specific gestational period, indicating compromised growth. This condition stems from various maternal, placental, and fetal factors, all of which contribute to the restricted supply of oxygen and nutrients essential for proper fetal development. Under standing these mechanisms and ensuring timely diagnosis are crucial to minimizing adverse maternal and fetal health outcomes(1).

A primary cause of IUGR is placental insuf ficiency, where the placenta is unable to provide adequate oxygen and nutrients to the fetus. This insufficiency can result from maternal health issues such as hypertension, diabetes, and preeclampsia, which disrupt blood flow to the fetus. Additionally, lifestyle factors like smoking, alcohol consumption, and drug abuse during pregnancy exacerbate placental dysfunction, further heightening the risk of IUGR. Poor maternal nutrition, especially deficiencies in essential vitamins and minerals, also impairs fetal growth. Moreover, multiple gestations, such as twins or triplets, increase the likelihood of IUGR due to limited space and competition for nutrients(2).

IUGR is categorized into two main types based on the pattern of growth restriction: symmetric and asymmetric. Symmetric IUGR is characterized by proportional growth restriction, affecting the entire body equally. This form is typically associated with early pregnancy insults, including genetic abnormalities or intrauterine infections that disrupt normal development from the earliest stages. On the other hand, asymmetric IUGR is marked by disproportionate growth, where the head remains relatively larger than the abdomen. This occurs primarily when placental insufficiency develops later in pregnancy, leading to the redirection of blood flow towards vital organs like the brain, at the expense of the liver and abdominal growth. The distinction between these two types is crucial for understanding the underlying cause and implementing effective management strategies(3).

The diagnosis of IUGR relies on ultrasound imaging to assess fetal size and growth patterns. Key fetal parameters, including head circumference, abdominal circumference, and femur length, are measured and compared to standardized growth charts for the respective gestational age. When these measurements fall below the 10th percentile, IUGR is suspected. Doppler ultrasound is also a vital tool in evaluating blood flow through the umbilical artery and other fetal vessels, providing insights into placental function and identifying signs of compromised fetal circulation. Furthermore, non-stress tests are employed to monitor the fetal heart rate in response to movements, offering additional information about fetal well-being. These diagnostic approaches enable early detection of IUGR, facilitating timely interventions to optimize fetal health outcomes(4).

Managing IUGR necessitates regular monitoring of fetal development and health status through serial ultrasounds and non-stress tests. If signs of fetal distress or severe growth restriction are detected, early delivery may be considered to prevent adverse outcomes. The timing of delivery is a critical decision based on the severity of growth restriction and the gestational age of the fetus. For cases nearing full term, delivery is often recommended to mitigate risks associated with continued in-utero stress. Managing maternal conditions like hypertension and diabetes is essential to improve maternal health and enhance fetal growth. Lifestyle modifications, including cessation of smoking and improving dietary intake, are strongly recommended to reduce the risk of IUGR. In situations where early delivery is anticipated, corticosteroid administration may be used to accelerate fetal lung maturation, thereby reducing neonatal complications (5).

IUGR significantly increases the risk of several complications, including preterm birth, which exposes neonates to respiratory distress and other developmental challenges. Furthermore, infants born with IUGR are at heightened risk of perinatal asphyxia due to inadequate oxygen supply, potentially resulting in long-term developmental impairments. Feeding difficulties, hypoglycemia, and delayed developmental milestones are also common concerns in these infants. These risks highlight the necessity for meticulous monitoring during pregnancy and in the neonatal period to optimize health outcomes. Early detection and timely intervention are vital to reducing the risk of long-term complications and enhancing both maternal and neonatal health(6).

The importance of early and accurate diagnosis of IUGR cannot be overstated, as it directly influences maternal and fetal health outcomes. Early identification allows healthcare providers to recognize contributing factors such as hypertension, diabetes, or placental abnormalities and initiate appropriate interventions.

For instance, managing high blood pressure or gestational diabetes can improve placental function, enhancing oxygen and nutrient delivery to the fetus. In cases where infections are suspected, prompt treatment can prevent further complications. By addressing the root causes of IUGR, medical interventions can be tailored to improve both maternal and fetal health outcomes.

Once IUGR is detected, more frequent and detailed monitoring becomes crucial. Regular ultrasounds are performed to assess fetal growth, and Doppler studies are employed to evaluate blood flow in the umbilical artery and other vessels. These assessments help detect placental insufficiency early, allowing for timely medical intervention. Non-stress tests also play an essential role in evaluating fetal health by monitoring heart rate responses to fetal movements. This comprehensive monitoring strategy enables healthcare providers to identify signs of fetal distress promptly and act accordingly to safeguard maternal and fetal health(7).

The timing of delivery in IUGR is crucial, with early delivery required in severe cases to prevent stillbirth or adverse outcomes, while milder cases may benefit from continued gestation if fetal well-being is maintained. Accurate diagnosis guides delivery timing and method, ensuring optimal outcomes for mother and baby. When early delivery is necessary, corticosteroids are administered to accelerate lung development, enhancing neonatal survival. Advanced imaging techniques like high-resolution ultrasound, MRI, and Doppler ultrasound enable precise visualization of fetal growth and placental function, allowing for early detection of abnormalities. Timely intervention based on these findings reduces perinatal complications and improves neonatal health(8).

The study aims to evaluate the role of color Doppler indices in diagnosing intrauterine growth restriction (IUGR) in pregnancy, focusing on early and late-onset IUGR. It further assesses the utility of Doppler velocimetry of the umbilical artery, middle cerebral artery, and ductus venosus in non-anomalous fetuses with suspected IUGR during the second and third trimesters in high-risk singleton pregnancies.

MATERIALS AND METHODS

This single centric, prospective, observational, cross-sectional study was conducted in the Depar tment of Radiology, Sri Siddhartha Medical College Hospital and Research Centre, Tumkur, over 24 months (April 2023 to March 2025). It assessed the role of color Doppler indices, including umbilical artery (UA), middle cerebral artery (MCA), and ductus venosus Doppler velocimetry, in diagnosing intrauterine growth restriction (IUGR) in singleton pregnancies. Inclusion criteria included suspected IUGR with AC and EFW below the 10th percentile for gestational age and high-risk pregnancies. Multiple pregnancies and fetuses with congenital anomalies were excluded. Ethical approval and informed consent were obtained, ensuring confidentiality.

RESULTS

The gestational age distribution as assessed by ultrasound (USG), indicating that the majority of participants (39%) were within the 31–35 weeks range. The mean gestational age was found to be 29.57 ± 0.47 weeks, reflecting a predominant concentration in the mid-third trimester.

Table 1: Clinical Presentation of the antenatal mothers

Clinical Presentation	Frequency	Percentage
Pih	46	46.00
Oligohydramnios	16	16.00
Anemia	11	11.00
Diabetes	9	9.00
Maternal smoking	2	2.00
Congenital anomaly	4	4.00
Only IUGR	12	12.00
Total	100	100.00

The table illustrates the distribution of clinical presentations among the study participants. Pregnancy-induced hyper tension (PIH) was the most common condition (46%), followed by oligohydramnios (16%) and anemia (11%). Diabetes accountedfor 9%, while maternal smoking and congenital anomalies were observed in 2% and 4% of cases, respectively. Isolated IUGR represented 12% of the total cases.

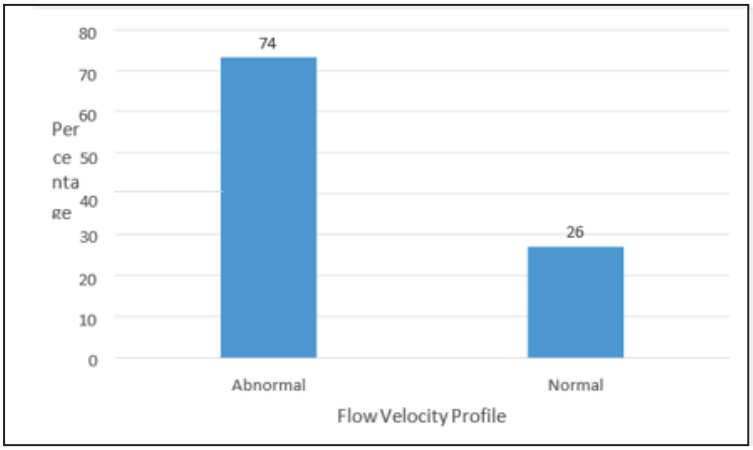

Figure 1: Flow Velocity Profile

The Doppler analysis of the uterine artery revealed that 74% of cases exhibited abnormal Resistive Index (RI) and Diastolic Notch, indicating compromised uteroplacental blood flow linked to preeclampsia and IUGR risk. Only 26% had normal findings, suggesting adequate placental perfusion. These results emphasize the importance of uterine artery Doppler in identifying high-risk pregnancies for timely intervention.

Table 2: Umbilical Artery Pulastility Index

Umbilical Artery PI	Number	Percentage
Elevated	67	67.0
Normal	33	33.0
Total	100	100.0

The table shows that 67% of cases exhibited elevated Umbilical Artery Pulsatility Index (PI), indicating increased resistance to blood flow and potential placental insufficiency. Only 33% had normal PI values, suggesting adequate placental perfusion. Elevated PI is commonly associated with compromised fetal circulation, highlighting the importance of Doppler monitoring for early detection of fetal distress.

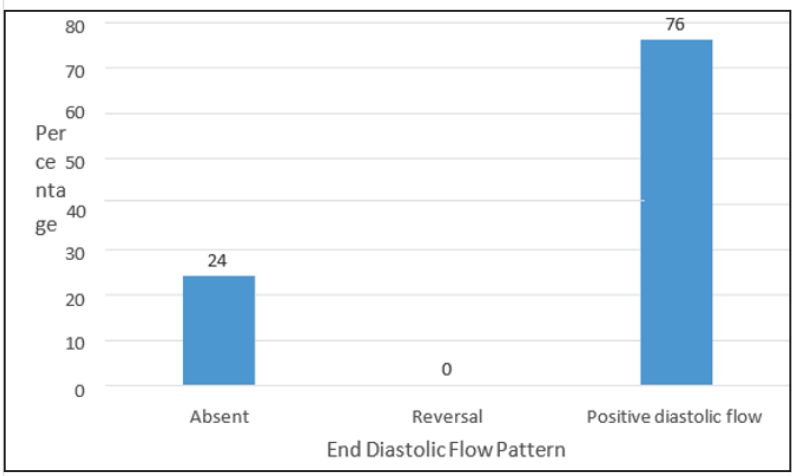

Figure 2: Distribution of Absent or Reversal of end Diastolic Flow

The analysis of Umbilical Artery End Diastolic Flow revealed that 24% of cases had absent end-diastolic flow, indicating elevated placental resistance and heightened risks of fetal hypoxia and IUGR. In contrast, 76% showed positive diastolic flow, reflecting normal circulation, with no cases of reversed flow. Absent diastolic flow warrants close monitoring to prevent adverse perinatal outcomes.

Table 3: Middle Cerebral Artery Doppler examination

Middle Cerebral Artery PI	Number	Percentage
Decreased	42	42
Normal	58	58
Total	100	100

The table illustrates Middle Cerebral Artery (MCA) Doppler findings, showing that 42% of cases had decreased Pulsatility Index (PI), indicating potential brain-sparing effects due to fetal hypoxia or compromised placental function. The remaining 58% displayed normal PI, suggesting adequate cerebral perfusion. Reduced MCA PI is often associated with intrauterine growth restriction (IUGR) and adverse fetal outcomes, necessitating closer monitoring.

Table 4: Ratio of PI of MCA to PI of umbilical artery

MCA / Umb A PI	Number	Percentage
MCA/Umb A PI (<1.08)	65	65
Normal	35	35
Total	100	100

The table demonstrates the ratio of the Pulsatility Index (PI) of the Middle Cerebral Artery (MCA) to the Umbilical Artery (Umb A), showing that 65% of cases had an abnormal ratio (<1.08), indicating brain-sparing physiology often associated with fetal hypoxia. Only 35% had normal ratios, suggesting adequate cerebral and placental perfusion, highlighting the need for closer monitoring in abnormal cases.

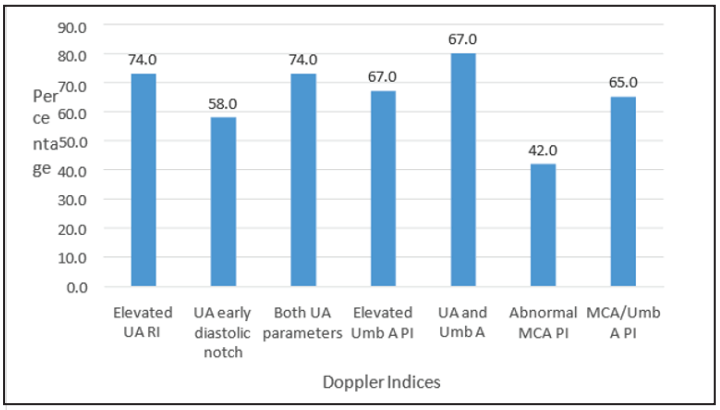

Figure 3: Characteristic of Doppler Indices

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MCA/Umb A PI (<1.08)	65	65
Normal	35	35
Total	100	100

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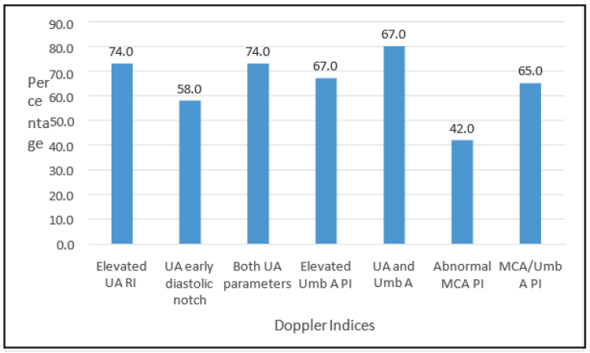

Figure 3: Characteristic of Doppler Indices

The Doppler analysis revealed vascular abnormalities with elevated umbilical artery RI in 74% of cases, a persistent early diastolic notch in the uterine artery in 58%, and decreased MCA PI in 42%, indicating placental insufficiency, fetal hypoxia, or blood flow redistribution, underscoring Doppler's significance in detecting fetal distress and predicting adverse outcomes.

Table 5: Comparison of Doppler indices with adverse perinatal outcome

Doppler Index	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Diagnostic Accuracy
UA diastolic notch	15	8	3	4	78.90%	72.70%	83.30 %	66.70 %	76.70%
UA RI	17	6	5	2	89.50%	54.50%	77.30 %	75.00 %	76.70%
Umb A PI	19	9	2	0	100.00 %	81.80%	90.50 %	100.0 0%	93.30%
MCA PI	12	11	0	7	63.20%	100.00 %	100.0 0%	61.10 %	76.70%
MCA/Umb PI	19	10	1	0	100.00 %	90.90%	95.00 %	100.0 0%	96.70%

The table compares Doppler indices with adverse perinatal outcomes, showing that Umbilical Artery PI and MCA/Umb A PI had the highest sensitivity (100%) and diagnostic accuracy (93.3% and 96.7%, respectively), indicating strong predictive value. MCA PI showed perfect specificity (100%) but lower sensitivity (63.2%). These findings underscore the reliability of Doppler parameters in identifying high-risk pregnancies.

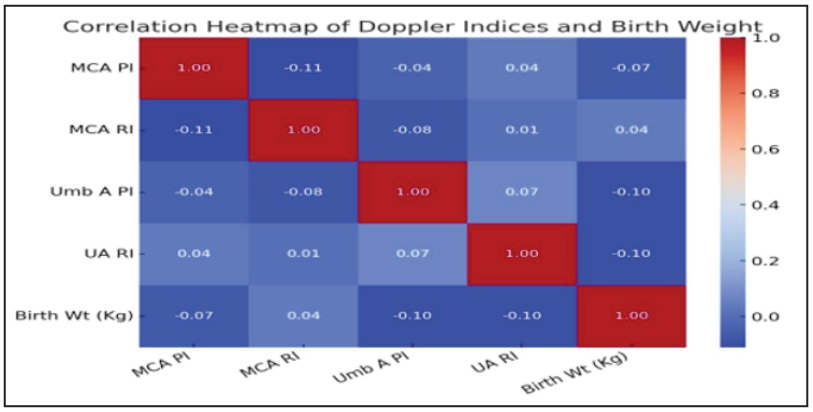

Figure 4: Correlation coefficients between Doppler indices and birth

The correlation analysis reveals weak or no associations between Doppler indices (MCA PI, MCA RI, Umb A PI, UA RI) and birth weight, suggesting limited predictive value for fetal weight. Minimal inter-correlation among these indices indicates independent cerebral and placental blood flow dynamics, highlighting the influence of other maternal or clinical factors.

Table 6: Statistical comparisons (t-tests) between Early vs. Late Onset IUGR for Doppler indices and birth weight

	t-statistic	p-value
MCA PI	-1.09	0.30
MCA RI	0.39	0.71
Umb A PI	0.83	0.42
UA RI	4.82	0.00
Birth Wt (Kg)	-1.17	0.26

The table presents t-statistics and p-values for Doppler indices and birth weight. Only UA RI showed statistical significance (p = 0.00), indicating a strong association with adverse outcomes. All other parameters (MCA PI, MCA RI, Umb A PI, and birth weight) were not statistically significant (p > 0.05), suggesting minimal predictive value for these indices.

REPRESENTATIVE CASES

Case no 1: 25 yr old primigravida with 32 weeks 0 days showed the following doppler indices

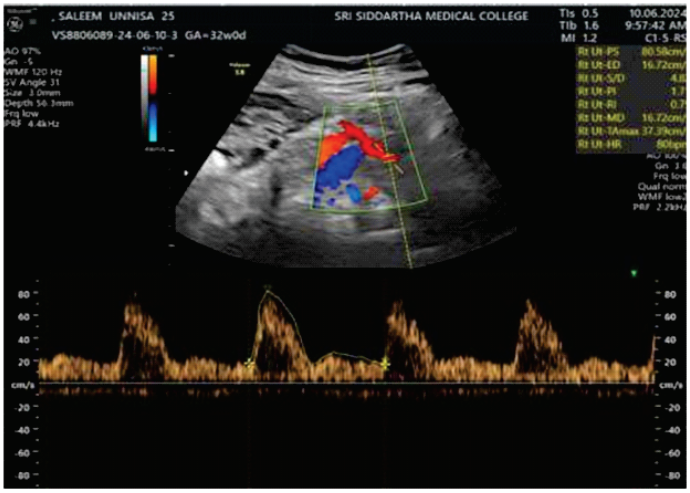

Figure 5: Right uterine artery shows persistent early diastolic notch

Case no 2: 19 yr old primigravida with 24 weeks 4 days showed the following doppler indices

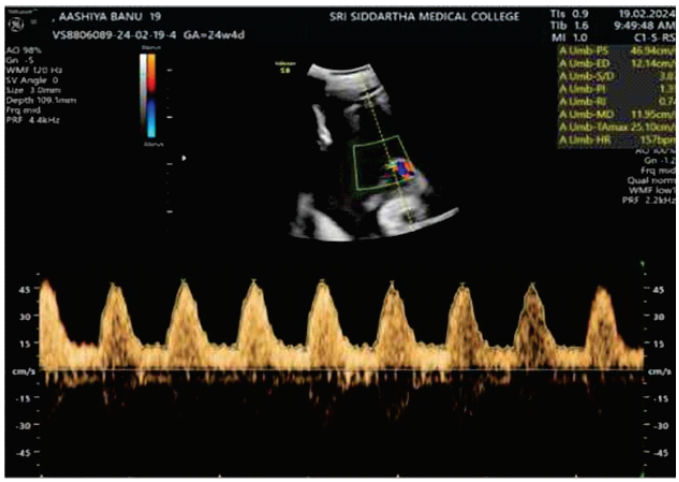

Figure 6: Umbilical artery Pulsatile index (PI) elevated

Case no 3: 29 yr old Multi gravida with 22 weeks 4 days showed the following doppler indices

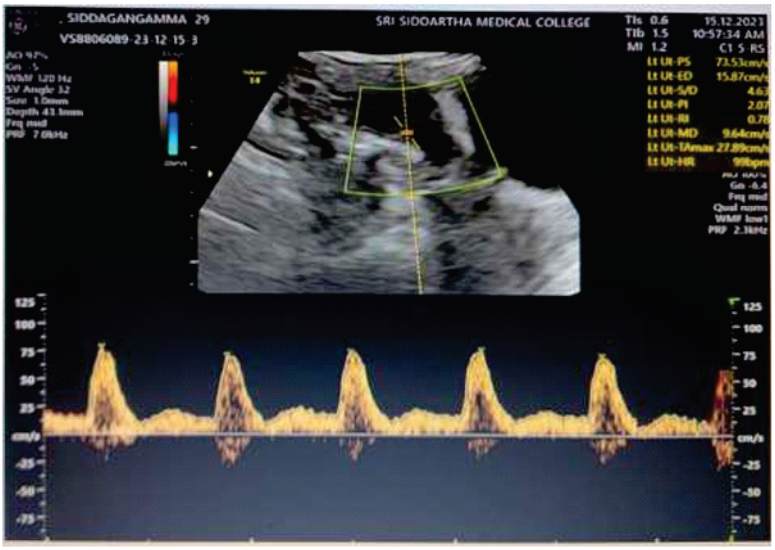

Figure 7: Left uterine artery shows early end diastolic notch

DISCUSSION

In a study of 100 pregnant women with a mean age of 29.26 ± 6.60 years, the majority were aged 31–35 years (30%), followed by 26–30 years (22%) and 21–25 years (18%). This distribution aligns with Sujana KR et al. (2023) and Refaat MM et al. (2021), who emphasized the 25–35 age range's vulnerability to IUGR. Doppler studies, including Aditya I et al. (2016), highlighted 26–35 weeks as critical for IUGR detection, stressing the significance of Doppler velocimetry during this period(9-11).

In our study, pregnancy-induced hypertension (46%) was the most common condition, followed by oligohydramnios (16%) and anemia (11%), consistent with Albu AR et al. (2014) and Berkley E et al. (2012), who linked these conditions with IUGR. Doppler indices showed mean values of MCA PI (1.50 ± 0.27), MCA RI (0.66 ± 0.09), Umb A PI (1.22 ± 0.38), and UA RI (0.60 ± 0.12), with an average birth weight of 2.86 ± 0.89 kg, aligning with Rizzo G et al. (2020) and Yadav SS et al. (2020). Additionally, 74% had elevated UA RI, reflecting increased placental resistance, consistent with Ouda SS et al. (2022). Among these, 28% had unilateral elevation, 46% had bilateral elevation, and 26% showed no elevation, supporting findings by Maršál K (2002) on the stronger link between bilateral UA RI and IUGR (12-17).

In our study, 58% of cases showed a persistent early diastolic notch, indicating placental insufficiency linked to IUGR, while 42% did not. This aligns with findings by Mai K et al. (2021), who associated early diastolic notches with IUGR and adverse outcomes. Moreover, 25% exhibited a unilateral notch, 33% had bilateral notches, and 42% showed none. These observations are consistent with Gebb J et al. (2011) and Baschat AA et al. (2005), who reported that bilateral notches are more predictive of IUGR and adverse pregnancy outcomes(18-20).

In our study, 74% of cases exhibited abnormal uterine artery flow velocity profiles, while 26% were normal, mirroring findings by Figueras F et al. (2018), who reported strong associations between abnormal Doppler indices and IUGR . Additionally, 67% of pregnancies showed elevated umbilical artery pulsatility index (PI), while 33% had normal PI, consistent with Haram K et al. (2006) who linked elevated PI with reduced placental perfusion and adverse fetal outcomes. These results underscore the significance of Doppler indices in identifying high-risk pregnancies for IUGR(21, 22).

In our study, 24% of cases showed absent end-diastolic flow (EDF), while 76% exhibited positive diastolic flow, with no instances of reversed EDF. This aligns with Baschat AA (2004), who identified absent or reversed EDF as markers of severe IUGR, indicating increased placental resistance. Additionally, 67% of pregnancies showed changes in both uterine and umbilical arteries, with 7% having only uterine artery changes, totaling 74% with uterine abnormalities. This supports findings by Kaur T et al. (2020) that abnormalities in both arteries heighten IUGR risk. Furthermore, 42% had a decreased middle cerebral artery (MCA) pulsatility index (PI), while 58% were normal, consistent with Fan H et al. (2024) and Sharma U, who linked decreased MCA PI with fetal hypoxia and brain-sparing mechanisms in IUGR. These findings underscore the role of Doppler indices in assessing fetal perfusion and identifying IUGR risk(23-26).

In our study, 65% of cases had an MCA/Umbilical Artery PI ratio of less than 1.08, consistent with Vayssière C et al. (2015), linking it to IUGR. Additionally, 74% had elevated UA RI, 58% showed early diastolic notches, and 67% had elevated Umb A PI, aligning with Bamfo JE et al. (2011). Doppler analysis demonstrated high sensitivity and diagnostic accuracy for UA diastolic notch, Umb A PI, and MCA/Umb PI, supporting findings by Morales-Roselló J et al. (2014). Weak negative correlations were observed between Doppler indices and birth weight, mirroring Nazir ZA et al. (2011). Early-onset IUGR showed higher UA PI (1.17 vs. 1.06) and UA RI (0.67 vs. 0.48), reflecting more severe placental insufficiency, consistent with Caradeux J et al. (2019).(27-31).

CONCLUSION

Color Doppler velocimetry is a vital diagnostic tool for assessing fetal circulation and placental function in pregnancies complicated by IUGR. Key findings include the umbilical artery Doppler as a reliable predictor of placental insufficiency, MCA Doppler abnormalities reflecting brain-sparing mechanisms linked to fetal hypoxia, and CPR <1.08 as a strong marker for fetal distress and adverse neonatal outcomes. Uterine artery Doppler abnormalities are associated with early-onset IUGR and preeclampsia risk. Early detection of these Doppler abnormalities enables better perinatal management, including timely delivery planning and neonatal care, high - lighting the need for its integration into routine antenatal screening for high-risk pregnancies.

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REFERENCE

1. Nardozza LMM, Caetano ACR, Zamarian ACP, Mazzola JB, Silva CP, Marçal VMG, et al. Fetal growth restriction: current knowledge. 2017;295:1061-77.
2. Krishna U, Bhalerao SJTJoO, India Go. Placental insufficiency and fetal growth restriction. 2011;61:505-11.
3. Suhag A, Berghella VJCO, Reports G. Intrauterine growth restriction (IUGR): etiology and diagnosis. 2013;2(2): 102-11.
4. Albu A, Horhoianu I, Dumitrascu M, Horhoianu VJJom, life. Growth assessment in diagnosis of fetal growth restriction. Review. 2014;7(2):150.
5. Reeves S, Galan HL. Fetal growth restriction. Maternal-fetal evidence based guidelines: CRC Press; 2017. p. 436-55.
6. Pike K, Pillow JJ, Lucas JS, editors. Long term respiratory consequences of intrauterine growth restriction. Seminars in fetal and neonatal medicine; 2012: Elsevier.
7. Guerby P, Bujold EJJp. Early detection and prev- ention of intrauterine growth restriction and its consequences. 2020;174(8):749-50.
8. Imdad A, Yakoob MY, Siddiqui S, Bhutta ZAJBph. Screening and triage of intrauterine growth restriction (IUGR) in general population and high risk pregnancies: a systematic review with a focus on reduction of IUGR related stillbirths. 2011;11:1-12.
9. Refaat MM, Shalaan AJBmj. Role of ultrasound and color flow doppler in diagnosis of intrauterine growth restriction. 2021;38(2):725-40.
10. Aditya I, Tat V, Sawana A, Mohamed A, Tuffner R, Mondal TJJon-pm. Use of Doppler velocimetry in diagnosis and prognosis of intrauterine growth restriction (IUGR): A Review. 2016;9(2):117-26.
11. Sujana KRJPJoMS. Role of colour doppler indices in diagnosing intrauterine growth restriction in high risk pregnancies in second and third trimester. 2023;12(1):10-6.
12. Berkley E, Chauhan SP, Abuhamad A, obstetrics SfM-FMPCJAjo, gynecology. Doppler assessment of the fetus with intrauterine growth restriction. 2012;206 (4):300-8.
13. Albu A, Anca A, Horhoianu V, Horhoianu IJJom, life. Predictive factors for intrauterine growth restriction . 2014;7(2):165.
14. Yadav SS, Singh A, Yadav KJIJRCOG. 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. 2020;9(11): 4506-13.
15. Rizzo G, Mappa I, Bitsadze V, Słodki M, Khizroeva J, Makatsariya A, et al. Role of Doppler ultrasound at time of diagnosis of late-onset fetal growth restriction in predicting adverse perinatal outcome: prospective cohort study. 2020;55(6):793-8.
16. Sattar MA, Wahed SJA. Intrauterine growth restriction: role of ultrasound and color flow Doppler. 2011;9 (3):2.
17. Harkness UF, Mari GJCip. Diagnosis and manage ment of intrauterine growth restriction. 2004;31(4): 743-64.
18. Mai K, Naidu TJIJCMSR. Contribution of Color Doppler in Assessment of Intrauterine Fetal Growth

among High-Risk Pregnant Woman-A Observational Study. 2021;6(2):20-4.
19. Baschat AAJEhd. Arterial and venous Doppler in the diagnosis and management of early onset fetal growth restriction. 2005;81(11):877-87.
20. Gebb J, Dar PeJBp, obstetrics rC, gynaecology. Colour Doppler ultrasound of spiral artery blood flow in the prediction of pre-eclampsia and intrauterine growth restriction. 2011;25(3):355-66.
21. Figueras F, Caradeux J, Crispi F, Eixarch E, Peguero A, Gratacos EJAjoo, et al. Diagnosis and surveil - lance of late-onset fetal growth restriction. 2018; 218(2):S790-S802. e1.
22. Haram K, Søfteland E, Bukowski RJIjog, obstetrics. Intrauterine growth restriction. 2006;93(1):5-12.
23. Baschat AAJO, survey g. Pathophysiology of fetal growth restriction: implications for diagnosis and surveillance. 2004;59(8):617-27.
24. Kaur T, Bhatt RKJIJRCOG. The predictive role of color doppler sonography in evaluating hypoxia and acidosis in intrauterine growth restriction fetuses: correlation with arterial blood gas analysis. 2020;9:1119-23.
25. Fan H, Li L, Hao CJTJoM-F, Medicine N. Clinical significance of three-dimensional power Doppler combined with two-dimensional Doppler ultrasonography for evaluating fetal growth restriction. 2024;37(1):2322610.
26. Sharma U, Sharma M, Kumar S. Role of color doppler sonography in the intrauterine growth restriction and perinatal outcome.
27. Vayssière C, Sentilhes L, Ego A, Bernard C, Cambourieu D, Flamant C, et al. Fetal growth restriction and intra-uterine growth restriction: guidelines for clinical practice from the French College of Gynaecologists and Obstetricians. 2015;193:10-8.
28. Bamfo JE, Odibo AOJJop. Diagnosis and management of fetal growth restriction. 2011;2011 (1):640 715.
29. Morales-Roselló J, Khalil A, Morlando M, Papageor ghiou A, Bhide A, Thilaganathan BJUiO, et al. Changes in fetal Doppler indices as a marker of failure to reach growth potential at term. 2014;43 (3):303-10.
30. Nazir Z, Hussain S, Azam MJA. Doppler Ultrasound Abnormalities In Intrauterine Growth Restric - tions. 2021;29(1):6.34.
31. Caradeux J, Martinez-Portilla RJ, Peguero A, Sotiriadis A, Figueras FJAjoo, gynecology. Diagnostic performance of third-trimester ultrasound for the prediction of late-onset fetal growth restriction: a systematic review and meta-analysis. 2019;220(5): 4 49-59. e19.

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