International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 24s, 2025
https://theaspd.com/index.php

Comparative Study of Umbilical and Cerebral Artery Flow Velocity in Normal and Foetal Growth Restriction

Dr. Vanishri P R[1], Prof. Dr. Ravindra S Pukale[2], Dr Aamer Ahmed Fairoze[3], Dr Lavanya C [4], Dr Divya Tagore[5]
[1]Junior Resident, Department of Obstetrics and Gynecology, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, B G Nagara, 571448, Karnataka, India
[2]Professor and Unit Chief, Department of Obstetrics and Gynecology, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, B G Nagara, 571448, Karnataka, India
[3]Senior Resident, Department of Obstetrics and Gynecology, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, B G Nagara, 571448, Karnataka, India
[4]Junior Resident, Department of Obstetrics and Gynecology, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, B G Nagara, 571448, Karnataka, India
[5]Junior Resident, Department of Obstetrics and Gynecology, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, B G Nagara, 571448, Karnataka, India
[*]**Corresponding author:** vinyapr29@gmail.com

ABSTRACT
Background: *Fetal growth restriction (FGR) is a major contributor to perinatal morbidity and mortality, frequently resulting from placental insufficiency. Doppler ultrasonography of the umbilical artery (UA) and middle cerebral artery (MCA) provides valuable insights into placental resistance and fetal adaptation.*
Aim: *To evaluate and compare the role of umbilical and cerebral artery Doppler in pregnancies with FGR and in normal fetuses.*
Methods: *This prospective cross-sectional study was conducted over 18 months (June 2023 – Dec 2024) in the Department of Obstetrics and Gynaecology, Adichunchanagiri Institute of Medical Sciences and Research Centre, Karnataka. Singleton pregnancies between 32–36 weeks were included. Women underwent ultrasound and color Doppler evaluation . UA and MCA pulsatility indices (PI), systolic/diastolic ratios (S/D), and cerebroplacental ratio (CPR) were measured. Estimated fetal weight was classified as appropriate for gestational age (AGA) or small for gestational age (SGA). Doppler findings were correlated with gestational age, fetal growth, and perinatal outcomes.*
Results: *Abnormal Doppler indices were significantly more common in FGR pregnancies compared to normal pregnancies. Elevated UA PI and S/D ratio indicated increased placental resistance, while reduced MCA PI demonstrated the "brain-sparing effect." Low CPR was strongly associated with adverse perinatal outcomes, including low birth weight, low APGAR scores, and NICU admission. In contrast, normal pregnancies exhibited progressively declining UA resistance and stable MCA PI with advancing gestation.*
Conclusion: *Combined assessment of UA and MCA Doppler, particularly CPR, is a reliable, non-invasive tool for differentiating constitutionally small from growth-restricted fetuses. Incorporating these Doppler parameters into routine antenatal surveillance enables early detection of fetal compromise and aids in optimizing delivery timing, thereby improving perinatal outcomes.*
Keywords: *Fetal growth restriction, Doppler ultrasonography, Umbilical artery, Middle cerebral artery, Cerebroplacental ratio, Perinatal outcome*

INTRODUCTION:

Fetal growth restriction (FGR) is a condition in which a fetus fails to achieve its genetic growth potential, most commonly due to placental insufficiency. It affects 5–10% of pregnancies and is strongly associated with stillbirth, neonatal morbidity, and long-term health risks, including cardiovascular and metabolic disease in adulthood.

Doppler ultrasonography is central to the evaluation of FGR, offering non-invasive assessment of fetal hemodynamics. The umbilical artery (UA) reflects placental resistance, with abnormal findings such as increased systolic/diastolic ratios, absent, or reversed end-diastolic flow indicating impaired placental perfusion. In contrast, the middle cerebral artery (MCA) provides insight into fetal adaptation to hypoxia. Under hypoxic stress, fetuses demonstrate a "brain-sparing effect," with reduced MCA resistance and pulsatility index (PI) to preserve cerebral oxygen delivery.

The integration of these circulations is expressed through the cerebroplacental ratio (CPR), defined as MCA PI/UA PI. A low CPR reflects both increased placental resistance and cerebral vasodilation, and has been consistently associated with adverse outcomes such as low birth weight, abnormal fetal heart rate patterns, and neonatal intensive care unit (NICU) admission.

Advances in Doppler technology and standardized indices have strengthened its role as a reliable, non-invasive tool for differentiating constitutionally small fetuses from those with pathological growth restriction. Early detection of abnormal UA, MCA, and CPR patterns enables risk stratification, optimization of delivery timing, and improved perinatal outcomes.

The present study evaluates and compares Doppler findings of the UA and MCA in normal and FGR pregnancies, with emphasis on the predictive value of CPR in relation to gestational age and perinatal outcome.

AIM OF THE STUDY:

To evaluate the role of umbilical and cerebral artery doppler in pregnancies with foetal growth restriction and normal foetuses

OBJECTIVES OF THE STUDY:

1. To determine the flow velocity of umbilical artery in normal and growth restricted pregnancy
2. To determine the flow velocity of foetal cerebral artery in normal and growth restricted pregnancy
3. To correlate gestation age with the doppler findings
4. To correlate the extent of foetal growth restriction and doppler findings

SECONDARY OBJECTIVES:

1. To assess the relationship between abnormal Doppler findings and perinatal outcomes such as birth weight, Apgar score, mode of delivery, and NICU admission.
2. To compare perinatal morbidity and mortality between growth-restricted and normal pregnancies in relation to Doppler parameters.

MATERIALS AND METHODS

1.STUDY DESIGN:

A prospective cross-sectional study

2.DURATION OF STUDY:

18 months from June 2023 to December 2024.

3.STUDY AREA: Adichunchanagiri Institute of Medical Sciences and Research centre(ACU), B.G. Nagara, Nagamangala Taluk, Mandya District.

4.STUDY PARTICIPANTS: Pregnant women with singleton pregnancy between 32–36 weeks were enrolled after informed consent.

Inclusion Criteria:

- All the patients with singleton pregnancy with normal and reduced fetal growth.
- Patients willing to participate in the study by giving written- informed consent

Exclusion Criteria:

- Patients with meconium stained amniotic fluid
- Patients with foetuses of known congenital abnormalities
- Recent teratogenic drug usage/vaginal drug instillation
- Patients with chronic illnesses

5.METHODOLOGY:

Maternal demographic and obstetric details were obtained using a structured questionnaire, followed by clinical examination. Gestational age was determined from the last menstrual period and confirmed by early ultrasound when available. Fetal biometry was measured, and estimated fetal weight (EFW) was calculated using the Hadlock formula. Fetuses with EFW <10th percentile were classified as small-for-gestational-age (SGA), while those between the 10th–90th percentile were considered appropriate-for-gestational-age (AGA).Flow velocity of umbilical and middle cerebral artery was measured in both normal and growth restricted pregnancy and the outcomes was correlated with fetal birth weight, APGAR and need for NICU admission.

6.**SAMPLE SIZE ESTIMATION:**
By applying the formula

$$z_{1-\alpha/2} * \sqrt{\sigma^2} = d - z_{1-\beta} * \sqrt{\sigma^2} \quad (I)$$

where z is the constant; z = 1.96; p is the prevalence; q = (1-p); d is the allowable error, which could be considered as 12.5% for our study. Sigma/ The variance around difference between the two study groups is equal to sum of variances around mean in each of the groups divided by the number of participants in that group.
In our study, p = 24%2 d = 24% Hence, the sample size is 200, and 100 in each group.

RESULTS:

1. **AGE GROUP:**

The distribution of maternal age was fairly similar between the normal and fetal growth restriction (FGR) groups, with the highest concentration in the 21–25 age range (55% in normal and 54% in FGR), followed by 26 to 30 years (29% in normal and 24% in FGR). Notably, more mothers aged 31–35 years were in the FGR group (9%) compared to the normal group (5%). The p-value (0.759) indicates no significant difference.

TABLE 1 :AGE WISE DISTRIBUTION

AGE		GROUP		P VALUE
		NORMAL	FGR	
18-20Years	Count	7	9	0.759
	%	7%	9%	
21-25Years	Count	55	54	
	%	55%	54%	
26-30Years	Count	29	24	
	%	29%	24%	
31-35Years	Count	5	9	
	%	5%	9%	
36-40Years	Count	4	4	
	%	4%	4%	
TOTAL	Count	100	100	

	%	100%	100%	

2. MENSTRUAL CYCLE:

Similarly, menstrual cycle regularity did not show a significant difference between groups (p 0.316), with almost all participants in both groups having regular cycles.

TABLE 2 :DISTRIBUTION BASED ON MENSTRUAL CYCLE

MENSTRUAL CYCLE		GROUP		P VALUE
		NORMAL	FGR	
NORMAL	COUNT	100	99	0.316
	%	100%	99%	
IRREGULAR	COUNT	0	1	
	%	0%	1%	
TOTAL	COUNT	100	100	
	%	100%	100%	

3. PARITY:

The distribution of parity was comparable, with primigravida mothers accounting for 39% of normal pregnancies (with no growth restriction) and 36% of FGR pregnancies whereas 64% of the FGR pregnancies were multigravida (p = 0.661).

TABLE 3:DISTRIBUTION BASED ON PARITY

GRAVIDA		GROUP		P VALUE
		NORMAL	FGR	
PRIMI	COUNT	39	36	0.661
	%	39%	36%	
MULTI	COUNT	61	64	
	%	61%	64%	
TOTAL	COUNT	100	100	
	%	100%	100%	

4. BMI:

BMI categories also showed no statistically significant difference (p = 0.203), though slightly more mothers with FGR fell in within the underweight (<18.5 kg/m²) and obese (35–39.9 kg/m²) categories.

TABLE 4: DISTRIBUTION BASED ON BMI

AGE		GROUP		P VALUE
		NORMAL	FGR	
<18.5kg/m^2	Count	1	2	0.203
	%	1%	2%	
18.5-22.9kg/m^2	Count	42	47	
	%	42%	47%	
23-24.9kg/m^2	Count	26	22	
	%	26%	22%	
25-29.9kg/m^2	Count	29	25	
	%	29%	25%	
30-34.9kg/m^2	Count	2	0	
	%	2%	0%	
35-39.9kg/m^2	Count	0	4	
	%	0%	40%	
TOTAL	Count	100	100	
	%	100%	100%	

5. **EFW:**

Estimated Fetal Weight (EFW) was significantly lower in the FGR group (2400.55 ± 505.12 g) compared to the normal group (2555.98 ± 522.39 g), with a p value of 0.036.

TABLE 5: EFW

EFW		GROUP		P VALUE
		NORMAL	FGR	
USG	**MEAN**	2555.98	2400.55	**0.036**
	SD	522.395	505.123	

6. **UAPI:**

Umbilical Artery Pulsatility Index (UAPI) was significantly higher in the FGR group (1.14 ± 0.18) compared to the normal group (0.97 ± 0.18, $p < 0.05$) showing high significance.

TABLE 6:UAPI

UAPI	GROUP		P VALUE
	NORMAL	FGR	
MEAN	0.97	1.14	<0.05
SD	0.18	0.18	

7. MCAPI

The Middle Cerebral Artery Pulsatility Index (MCAPI) was lower in the FGR group (1.38 ± 0.19 vs. 1.52 ± 0.21) and was statistically significant ($p < 0.05$).

TABLE 7 :MCAPI

MCAPI	GROUP		P VALUE
	NORMAL	FGR	
MEAN	1.52	1.38	<0.05
SD	0.21	0.19	

8.CP RATIO:

The cerebroplacental ratio (CP ratio) was also significantly lower in the FGR group (1.23 ± 0.13 vs. 1.64 ± 0.40, $p < 0.05$).

TABLE 8: CP RATIO

CP RATIO	GROUP		P VALUE
	NORMAL	FGR	
MEAN	1.64	1.23	<0.05
SD	0.40	0.13	

9.Labour and Delivery Outcomes:

Spontaneous labor occurred more frequently in FGR cases (72.72% vs.50.66%), while induced labor was higher in normal pregnancies (49.33%).

TABLE 9: DISTRIBUTION BASED ON LABOUR

LABOUR	GROUP	
	NORMAL	FGR

SPONTANEOUS	COUNT	38	48
	%	50.66%	72.72%
INDUCED	COUNT	37	18
	%	49.33%	27.22%

10.PRETERM DELIVERY

Preterm delivery was significantly more common in the FGR group (65% vs. 34%, $p < 0.001$), highlighting the increased risk of early delivery in growth-restricted fetuses.

TABLE 10:PRETERM DELIVERY

PRETERM		GROUP		P VALUE
		NORMAL	FGR	
YES	COUNT	34	65	<0.001
	%	34%	65%	
NO	COUNT	66	35	
	%	66%	35%	
TOTAL	COUNT	100	100	
	%	100%	100%	

11. MODE OF DELIVERY:

The mode of delivery (FTVD vs. LSCS) was not significantly different (p = 0.163 for FTVD, p = 0.7 for LSCS).

TABLE 11: MODE OF DELIVERY

DELIVERY		GROUP		P VALUE
		NORMAL	FGR	
FTVD	COUNT	75	66	0.163
	%	75%	66%	
LSCS	COUNT	25	34	0.7

	%	25%	34%	

12. GESTATIONAL AGE AT DELIVERY:
Gestational age at delivery was significantly earlier in FGR pregnancies compared to normal pregnancies, with a higher proportion of preterm births in the FGR group. While 66% of normal pregnancies reached full term (37–40 weeks), only 35% of FGR pregnancies did. Conversely, 27% of FGR deliveries occurred between 32–34 weeks, and 30% between 34–37 weeks, compared to 12% and 18% in the normal group, respectively. Additionally, 8% of FGR pregnancies delivered extremely preterm (28–32 weeks) versus 4% in the normal group. The p-value of 0.027 indicates statistical significance, underscoring the heightened risk of premature delivery in growth-restricted fetuses.

TABLE 12 : GESTATIONAL AGE AT DELIVERY

GESTATIONAL AGE		GROUP		P VALUE
		NORMAL	FGR	
28-32WEEKS	COUNT	4	8	0.027
	%	4%	8%	
32-34WEEKS	COUNT	12	27	
	%	12%	27%	
34-37WEEKS	COUNT	18	30	
	%	18%	30%	
37-40WEEKS	COUNT	66	35	
	%	66%	35%	

13. DISTRIBUTION BASED ON BIRTH WEIGHT:
The distribution of birth weights highlights the stark differences between normal and FGR pregnancies. A significant proportion of FGR infants had extremely low birth weights, with 51% weighing less than 1 kg compared to only 13% in the normal group ($p < 0.05$). Additionally, 42% of FGR infants weighed between 1.5–2 kg, while no infants in the normal group fell within this range. Conversely, higher birth weight categories were predominantly seen in normal pregnancies: 41% weighed 2–2.5 kg, 36% weighed 2.5–3 kg, and 23% exceeded 3 kg, compared to only 27%, 16%, and 11% in the FGR group, respectively.

TABLE 13: DISTRIBUTION BASED ON BIRTH WEIGHT:

BIRTH WEIGHT		GROUP		P VALUE
		NORMAL	FGR	
<1KG	Count	13	51	<0.05
	%	13%	51%	
1-1.5KG	Count	0	4	
	%	0%	4%	
1.5-2KG	Count	0	42	
	%	0%	42%	
2-2.5KG	Count	41	27	

	%	41%	27%	
2.5-3KG	Count	36	16	
	%	36%	16%	
>3KG	Count	23	11	
	%	23%	11%	

14. APGAR:
Though Apgar scores at 5 and 10 minutes were slightly lower in FGR infants, the difference was not statistically significant (p = 0.734 and p = 0.833, respectively).

TABLE 14: APGAR

APGAR		GROUP		P VALUE
		NORMAL	FGR	
5th minute	MEAN	7	6.93	0.734
	SD	-	0.36	
10th minute	MEAN	9	8.98	0.833
	SD	-	0.14	

15. NICU ADMISSION:
However, NICU admissions were significantly higher in the FGR group (51% vs. 13%, p = 0.02), reflecting the increased morbidity risk.

TABLE 15: NICU ADMISSION

NICU ADMISSION		GROUP		P VALUE
		NORMAL	FGR	
YES	COUNT	13	51	0.02
	%	13%	51%	
NO	COUNT	87	49	
	%	87%	49%	
TOTAL	COUNT	100	100	
	%	100%	100%	

DISCUSSION:

This study evaluated the role of umbilical and cerebral artery Doppler in pregnancies with fetal growth restriction (FGR) compared to normal pregnancies. We found that umbilical artery PI was significantly elevated in FGR, while MCA PI and cerebroplacental ratio (CPR) were significantly reduced. These findings highlight increased placental resistance and the "brain-sparing" effect as adaptive responses to hypoxia, consistent with earlier reports by Adedo et al. and Gyawali et al.

Our results align with prior studies showing that abnormal UA Doppler reflects placental insufficiency, while reduced MCA PI indicates fetal redistribution of blood flow. CPR emerged as the most reliable parameter, strongly associated with adverse outcomes such as preterm birth, low birth weight, and increased NICU admissions. This supports previous evidence suggesting that CPR is superior to UA or MCA indices alone in predicting adverse outcomes.

In terms of perinatal outcomes, the FGR group showed significantly higher rates of preterm delivery, low birth weight, and NICU admission, in agreement with studies by Coenen et al. and Paladugu et al. Although Apgar scores were not significantly different in our study, previous studies have reported lower scores and higher neonatal mortality in FGR cases.

The clinical relevance of our findings lies in the ability of combined UA and MCA Doppler, particularly CPR, to differentiate between constitutionally small and truly growth-restricted fetuses. Routine use of these parameters can aid in timely intervention and optimization of delivery.

STRENGTH OF THE STUDY :

1. The study highlights the effectiveness of doppler ultrasound, particularly the Umbilical Artery Pulsatility Index(UAPI) and Cerebroplacental Ratio(CPR),in identifying fetuses at risk of growth restriction.
2. The study establishes a strong link between FGR and adverse neonatal outcomes such as increased NICU admission and low birth weight.
3. Findings support the role of doppler studies in routine antenatal care for early identification and intervention in high-risk pregnancies.

LIMITATIONS OF THE STUDY :

While our study provides valuable insights into the role of Doppler indices in assessing fetal growth restriction, it has several limitations.

The study was conducted in only one centre,it requires multicentric study to be
more specific.

The sample size, though balanced, may still be relatively small for broader generalizability. Additionally, the study focuses on mild to moderate FGR, and the findings may not fully capture the spectrum of severe growth restriction.

Potential confounding factors, such as socioeconomic status, and lifestyle factors, were not extensively explored.

The long-term neonatal outcomes beyond NICU admission were not assessed, limiting the ability to understand the lasting impact of growth restriction.

FUTURE ASPECTS:

Future research should focus on larger multicentric studies and integration of additional Doppler parameters such as ductus venosus and aortic isthmus for better prediction of adverse outcomes. Combining Doppler indices with biochemical markers and long-term follow-up of FGR infants can provide deeper insights. The use of artificial intelligence for automated Doppler analysis and development of standardized protocols may further enhance accuracy and clinical applicability.

CONCLUSION:

The study highlights the clinical utility of Doppler ultrasound, particularly the
Umbilical Artery Pulsatility Index (UAPI),middle cerebral artery Pulsatility Index and Cerebroplacental Ratio (CP ratio), in identifying fetuses at risk of growth restriction. FGR pregnancies are associated with higher placental resistance, lower estimated fetal weight, increased risk of preterm delivery, lower birth weights, and higher NICU admissions. The findings reinforce the importance of incorporating Doppler studies into routine antenatal care for timely intervention and optimized perinatal outcomes. Despite its limitations, the study contributes to the growing body of evidence advocating for Doppler velocimetry as

a critical tool in the management of high-risk pregnancies. Future research with larger, more diverse populations and longitudinal follow-up can further validate and expand upon these findings.

REFERENCES:

1.Arbeille P, Roncin A, Berson M, et al. Exploration of the fetal cerebral blood flow by duplex Doppler-linear array system in normal and pathological pregnancies. Ultrasound Med Biol. 1987;13(5):329-337.
2.Baschat AA. Fetal responses to placental insufficiency: an update. BJOG. 2004;111(10):1031-1041.
3.Griffin D, Cohen-Overbeek T, Campbell S. Fetal and umbilical Doppler flow waveform responses to maternal oxygen administration. Br J Obstet Gynaecol. 1984;91(11):1051-1057.
4.Eixarch E, Meler E, Iraola A, et al. Neurodevelopmental outcome in 2-year-old infants who were small-for-gestational-age term fetuses with cerebral blood flow redistribution. Ultrasound Obstet Gynecol. 2008;32(7):894-899.
5.Baschat AA, Gembruch U, Harman CR. The sequence of changes in Doppler and biophysical parameters as severe fetal growth restriction worsens. Ultrasound Obstet Gynecol. 2001;18(6):571-577.
6.Figueras F, Gardosi J. Intrauterine growth restriction: new concepts in antenatal surveillance, diagnosis, and management. Am J Obstet Gynecol. 2011;204(4):288-300.
7.Malhotra A, Allison BJ, Castillo-Melendez M, et al. Neonatal morbidities of fetal growth restriction: pathophysiology and impact. Front Endocrinol (Lausanne). 2019;10:55.
8.Murray E, Fernandes M, Fazel M, et al. Differential effect of intrauterine growth restriction on childhood neurodevelopment: a systematic review. BJOG. 2015;122(8):1062-1072.
9.Barker DJ. The origins of the developmental origins theory. J Intern Med. 2007;261(5):412-417.
10. Baschat AA. Neurodevelopment following fetal growth restriction and its relationship with antepartum parameters of placental dysfunction. Ultrasound Obstet Gynecol. 2011;37(5):501-514.
11. Crispi F, Crovetto F, Gratacos E. Intrauterine growth restriction and later cardiovascular function. Early Hum Dev. 2018;126:23-27.
12. Figueras F, Eixarch E, Meler E, et al. Small-for-gestational-age fetuses with normal umbilical artery Doppler have suboptimal perinatal and neurodevelopmental outcomes. Eur J Obstet Gynecol Reprod Biol. 2008;136(1):34-38. doi:10.1016/j.ejogrb.2007.02.016.
13. Flenady V, Koopmans L, Middleton P, et al. Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. Lancet. 2011;377(9774):1331-1340. doi:10.1016/S0140-6736(10)62233-7.