

# Study Of Doppler Indices Of The Umbilical And Fetal Middle Cerebral Arteries Above 28 Weeks Of Normal Gestation In A Medical College Of Eastern India.

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## Abstract

### Background

Measurement of Doppler indices forms an integral part of monitoring pregnancy non invasively. They provide an idea of fetal well being and help in taking appropriate steps at appropriate time in case of growth derangements. While there are many studies regarding normal range of Doppler indices in western population, few are there for the Indian subcontinent, especially for the eastern parts. Thus, this study has been conducted to establish a normal range of Doppler indices of the umbilical and middle cerebral arteries for better obstetric outcome.

### Objective

To establish a normal reference range of Doppler indices for monitoring fetal well-being after 28 weeks of gestation in the eastern population of India

### Material and Methods

511 patients above 28 weeks of gestation were included for the color doppler study of umbilical artery (UA) and middle cerebral artery (MCA). Angle independent Doppler indices like pulsatility index (PI), resistive index (RI) and cerebroplacental ratio (CPR) were calculated in each case. All cases were followed up till delivery and perinatal outcomes were recorded.

### Results

Negative correlation was noted between MCA PI and RI with gestational age. UA PI and RI also showed a gradual fall over the gestational age with negative correlation. There was a significant correlation between MCA PI and UA PI with their respective RI values. A negative correlation was noted between CP ratio and gestational age. CP ratio also showed a positive correlation with MCA PI and a negative correlation with UA PI.

### Conclusion

We would like to recommend the following range of normal Doppler parameters in 28-40 weeks of gestational age in eastern population of India:

- Middle cerebral artery (MCA)
  1. Pulsatility Index (PI):  $1.62 \pm 0.42$
  2. Resistive Index (RI):  $0.78 \pm 0.12$
- Umbilical artery (UA)
  1. Pulsatility Index (PI):  $0.94 \pm 0.23$
  2. Resistive Index (RI):  $0.60 \pm 0.09$

**Keywords:** Color Doppler ultrasonography, umbilical artery, middle cerebral artery, cerebroplacental ratio

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## **I. Introduction**

Colour Doppler ultrasonography has now become a part of routine standard obstetric care. Their main advantage lies in non invasive monitoring of fetal growth and well being. Many vessels have been studied using color doppler and they provide a comprehensive idea of fetal circulation and uteroplacental sufficiency. Out of these vessels, umbilical and middle cerebral arteries are the most evaluated ones as they can be easily traced compared to other vessels. Umbilical artery Doppler indices indicate condition of peripheral circulation while middle cerebral artery indices indicate fetal cerebral circulation. Middle cerebral artery indices indicate brain sparing effect in cases of fetal anemia. Intra uterine growth restriction can also be diagnosed based on Doppler indices of these arteries and their characteristic waveforms. Cerebroplacental ratio, a value free of inter and intra observer variation, can be calculated from the Doppler indices of umbilical artery and middle cerebral artery arteries.

Utilization of Doppler values for monitoring pregnancy dates back to late 1970s when Fitzgerald et al reported the use of Doppler velocimetry in fetal growth restriction. Since then many advancements have occurred both in hardware as well as techniques of Doppler velocimetry and many studies have been conducted in attempt to establish normal reference range values of Doppler indices. While there are many such studies in western literature, few are there for people of Indian subcontinent especially in the eastern parts.

The aim of this study was to find the value of pulsatility index (PI), resistive index (RI) of fetal umbilical and middle cerebral arteries and then calculate the cerebroplacental ratio (CP) above 28 weeks of normal gestation and thus establish a normal reference range if these indices.

## **II. Materials And Methods**

The study was conducted as a prospective observational study at the Department of Radio diagnosis on 511 antenatal patients referred from the outpatient department of Obstetrics and Gynecology of a tertiary care and teaching hospital from January 2023 to December 2023. Informed consent was obtained from each patient. All studies were conducted adhering to the pre-conception and pre-natal diagnostic (PCPNDT) guidelines.

### **Case definition**

Pregnant women above 28 weeks of gestation with singleton fetus were included.

### **Inclusion criteria**

Normal pregnancies above 28 weeks of gestation.

### **Exclusion criteria**

Previously diagnosed fetal anomalies, known complication in current pregnancy, bad obstetric history, multi fetal gestation, history of maternal smoking, maternal hypertension, diabetes mellitus or any other such maternal complications which are likely to influence the circulatory status in uterus, placenta or fetus.

### **Conduct of study**

Measurements were obtained using ALPINION ECUBE8 ultrasound machine with low frequency curvilinear transducer. Doppler waveforms of umbilical artery and middle cerebral artery were obtained along with Doppler indices with patients in semi-recumbent position.

Middle cerebral artery Doppler indices: Middle cerebral arteries were identified using colour Doppler and the artery closer to the probe was interrogated. Care was taken to exert as low transducer pressure as possible. Angle correction was done in each case so as to keep the values of insonation between 0 and 60 degrees. PI and RI were calculated in auto mode. The measurements were repeated and two successive readings showing same results were noted for the study

Umbilical artery RI and PI: A free loop of umbilical artery was identified and measurements were taken in the middle portion. Angle of insonation was kept within 0 and 60 degrees. PI and RI were measured in auto mode. The measurements were repeated and two successive readings showing same results were taken.

Cerebroplacental ratio: The ratio of middle cerebral artery PI to the umbilical artery PI was calculated for each case.

Data collected were entered in appropriately designed Microsoft excel worksheets

Statistical analysis: data collected were analyzed using software SPSS version 17.0 for windows.

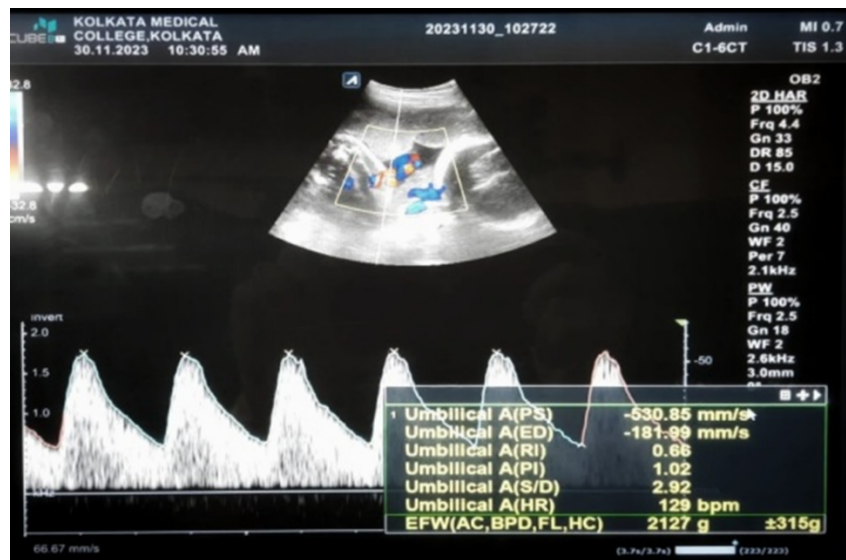


FIGURE 1: MEASUREMENT OF UMBILICAL ARTERY DOPPLER INDICES

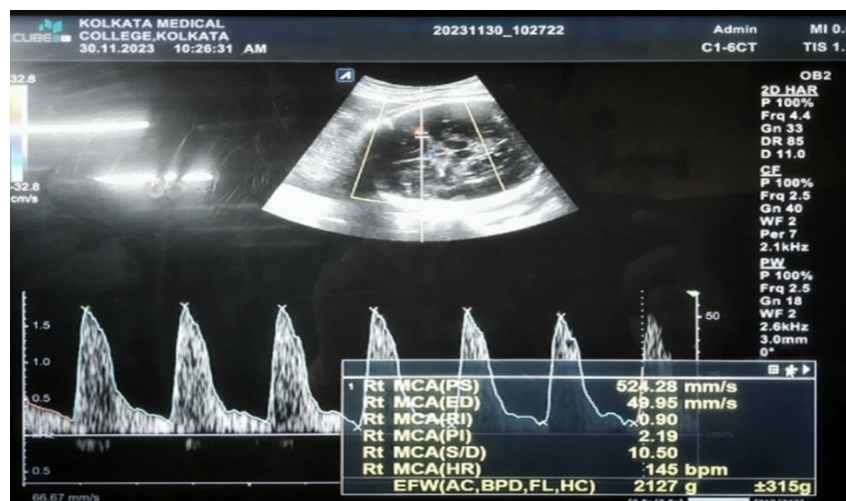


FIGURE 2: MEASUREMENT OF MIDDLE CEREBRAL ARTERY DOPPLER INDICES

### III. Results

In this study a total of 511 participants were included. Maximum number of participants belonged to the age range of 26 to 30 years (216, 42.3%). Majority of the cases were 2<sup>nd</sup> gravid (222, 43.4%). Maximum number of cases were in 35 weeks of gestation while minimum were in 40 weeks of gestation with mean gestational age of 33.5±2.9 weeks. Mean and standard deviation (SD) of MCA and UA PI, RI, and CP ratio along with their minimum and maximum values for each gestational age has been calculated and presented in tabulated form.

**PERIOD OF GESTATION (USG)**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	28	42	8.2	8.2	8.2
	29	28	5.5	5.5	13.7
	30	33	6.5	6.5	20.2
	31	31	6.1	6.1	26.2
	32	52	10.2	10.2	36.4
	33	46	9.0	9.0	45.4
	34	55	10.8	10.8	56.2
	35	77	15.1	15.1	71.2
	36	70	13.7	13.7	84.9
	37	45	8.8	8.8	93.7
	38	27	5.3	5.3	99.0
	39	4	.8	.8	99.8
	40	1	.2	.2	100.0
Total		511	100.0	100.0	

**TABLE 1: DISTRIBUTION OF STUDY POPULATION ACCORDING TO GESTATIONAL AGE**

**AGE CAT**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<20	73	14.3	14.3	14.3
	21-25	176	34.4	34.4	48.7
	26-30	216	42.3	42.3	91.0
	31-35	41	8.0	8.0	99.0
	36-40	5	1.0	1.0	100.0
Total		511	100.0	100.0	

**TABLE 2: DISTRIBUTION OF STUDY POPULATION ACCORDING TO AGE RANGE**

**GRAVIDA**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	130	25.4	25.4	25.4
2	222	43.4	43.4	68.9
3	112	21.9	21.9	90.8
4	41	8.0	8.0	98.8
5	3	.6	.6	99.4
6	1	.2	.2	99.6
7	2	.4	.4	100.0
Total	511	100.0	100.0	

**TABLE 3: DISTRIBUTION OF STUDY POPULATION ACCORDING TO GRAVIDITY**

MCA PI

PERIOD OF GESTATION (USG)	Minimum	Maximum	Mean	Std. Deviation
28	.98	3.88	1.7776	.45524
29	.96	2.30	1.6896	.35526
30	1.05	3.97	1.8976	.53350
31	1.20	2.14	1.7142	.28888
32	1.06	4.86	1.8246	.54248
33	1.20	2.31	1.5813	.27924
34	.70	3.63	1.5631	.46771
35	.86	2.34	1.5287	.33385
36	1.03	3.31	1.5517	.36913
37	.80	2.34	1.4838	.40124
38	.82	2.25	1.5115	.38548
39	.81	1.89	1.2875	.46220
40	1.48	1.48	1.4800	.
Total	.70	4.86	1.6279	.42537

**TABLE 4: VARIATION OF MCA PI VALUES WITH GESTATIONAL AGE**

MCA RI

PERIOD OF GESTATION (USG)	Minimum	Maximum	Mean	Std. Deviation
28	.54	1.50	.8164	.15416
29	.61	.86	.7804	.06221
30	.61	1.47	.8252	.13447
31	.60	.87	.7994	.06460
32	.63	1.61	.8152	.12676
33	.63	.91	.7765	.06233
34	.59	.87	.7660	.07731
35	.56	1.86	.7745	.14441
36	.61	1.50	.7737	.11966
37	.54	.87	.7444	.08537
38	.57	.90	.7478	.08290
39	.27	.89	.6700	.27362
40	.79	.79	.7900	.
Total	.27	1.86	.7815	.11500

**TABLE 5: VARIATION OF MCA RI VALUES WITH GESTATIONAL AGE**

UA PI

PERIOD OF GESTATION (USG)	Minimum	Maximum	Mean	Std. Deviation
28	.80	1.40	1.0336	.17988
29	.57	1.74	1.0193	.23868
30	.72	1.40	.9933	.14486
31	.70	1.49	1.0348	.21460
32	.55	3.42	1.0183	.38810
33	.18	1.56	.8904	.19162
34	.50	1.50	.8996	.18502
35	.66	1.36	.9057	.15703
36	.59	2.92	.9083	.28253
37	.59	1.25	.8509	.16583
38	.52	1.50	.8489	.18162
39	.60	.77	.6975	.07274
40	1.11	1.11	1.1100	.
Total	.18	3.42	.9367	.23433

**TABLE 6: VARIATION OF UA PI VALUES WITH GESTATIONAL AGE**

UA RI

PERIOD OF GESTATION (USG)	Minimum	Maximum	Mean	Std. Deviation
28	.49	.89	.6571	.08250
29	.44	.78	.6296	.07336
30	.51	.73	.6282	.05807
31	.50	.79	.6416	.07594
32	.41	1.20	.6360	.11455
33	.12	.79	.5830	.09271
34	.43	.82	.5851	.07988
35	.47	.73	.5891	.06044
36	.40	1.12	.5923	.09772
37	.40	.70	.5647	.07509
38	.42	.76	.5700	.07957
39	.40	.55	.5000	.06782
40	.67	.67	.6700	.
Total	.12	1.20	.6032	.08786

**TABLE 7: VARIATION OF UA RI VALUES WITH GESTATIONAL AGE**

CP RATIO

PERIOD OF GESTATION (USG)	Minimum	Maximum	Mean	Std. Deviation
28	1.14	3.23	1.7460	.43793
29	.64	2.61	1.7268	.47148
30	1.12	4.56	1.9524	.66718
31	1.12	3.06	1.7190	.45419
32	.99	2.86	1.8621	.44409
33	1.19	6.67	1.9063	.83594
34	.93	5.19	1.8095	.70404
35	1.05	3.19	1.7242	.43486
36	1.13	3.92	1.7743	.50298
37	.80	3.92	1.8053	.60998
38	.55	3.70	1.8641	.62941
39	1.05	2.74	1.8675	.69144
40	1.33	1.33	1.3300	.
Total	.55	6.67	1.8019	.56933

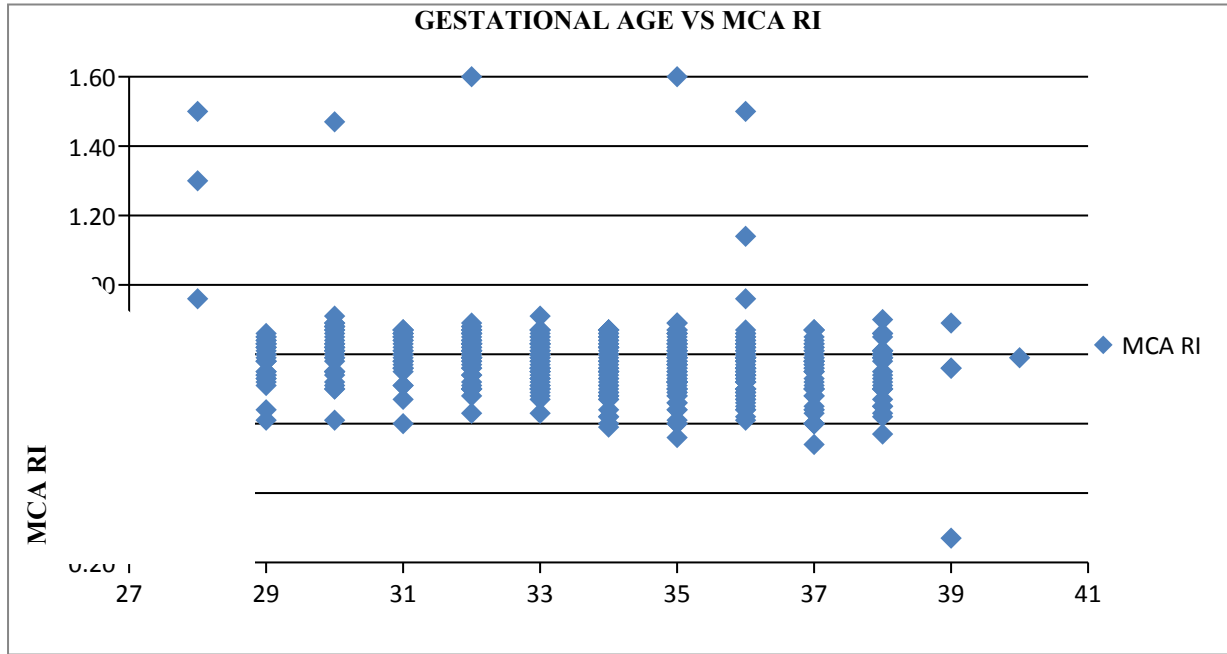
**TABLE 8: VARIATION OF CP RATIO VALUES WITH GESTATIONAL AGE**

		PERIOD OF GESTATION (USG)	MCA PI	MCA RI	CP RATIO 1	UA PI	UA RI
PERIOD OF GESTATION (USG)	Pearson Correlation Sig. (2-tailed) N	1 511					
MCA PI	Pearson Correlation Sig. (2-tailed) N	-.260** .000 511	1 511				
MCA RI	Pearson Correlation Sig. (2-tailed) N	-.184** .000 511	.742** .000 511	1 511			
CP RATIO 1	Pearson Correlation Sig. (2-tailed) N	-.003 .941 511	.589** .000 511	.384** .000 511	1 511		
UA PI	Pearson Correlation Sig. (2-tailed) N	-.255** .000 511	.361** .000 511	.322** .000 511	-.449** .000 511	1 511	
UA RI	Pearson Correlation Sig. (2-tailed) N	-.300** .000 511	.343** .000 511	.340** .000 511	-.437** .000 511	.859** .000 511	1 511

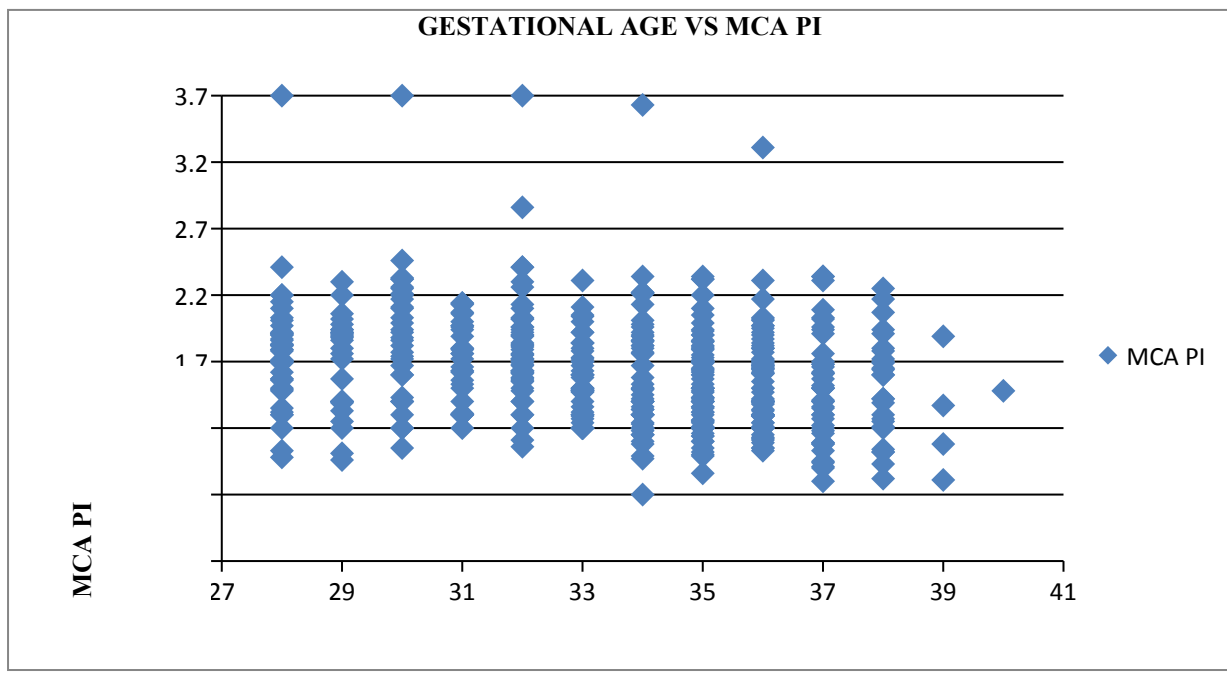
\*\* . Correlation is significant at the 0.01 level (2-tailed).

**TABLE 9: PEARSON'S CORRELATIONS AMONG VARIOUS VARIABLES**

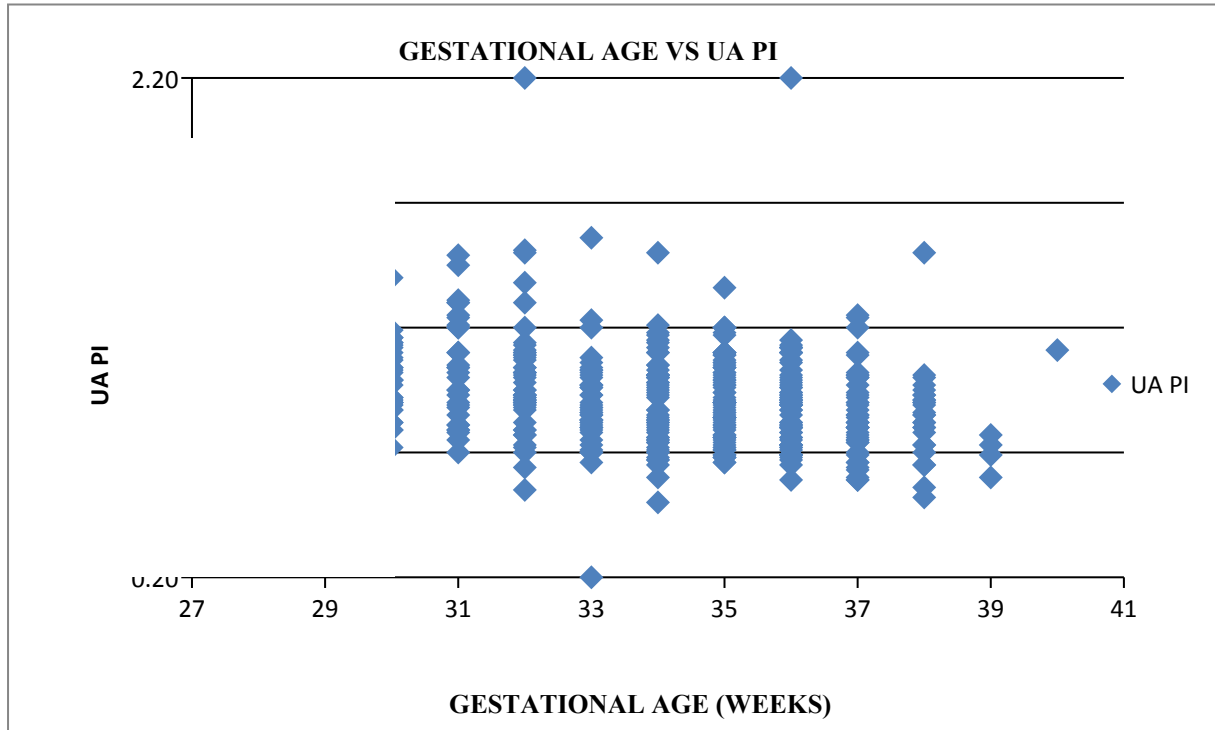




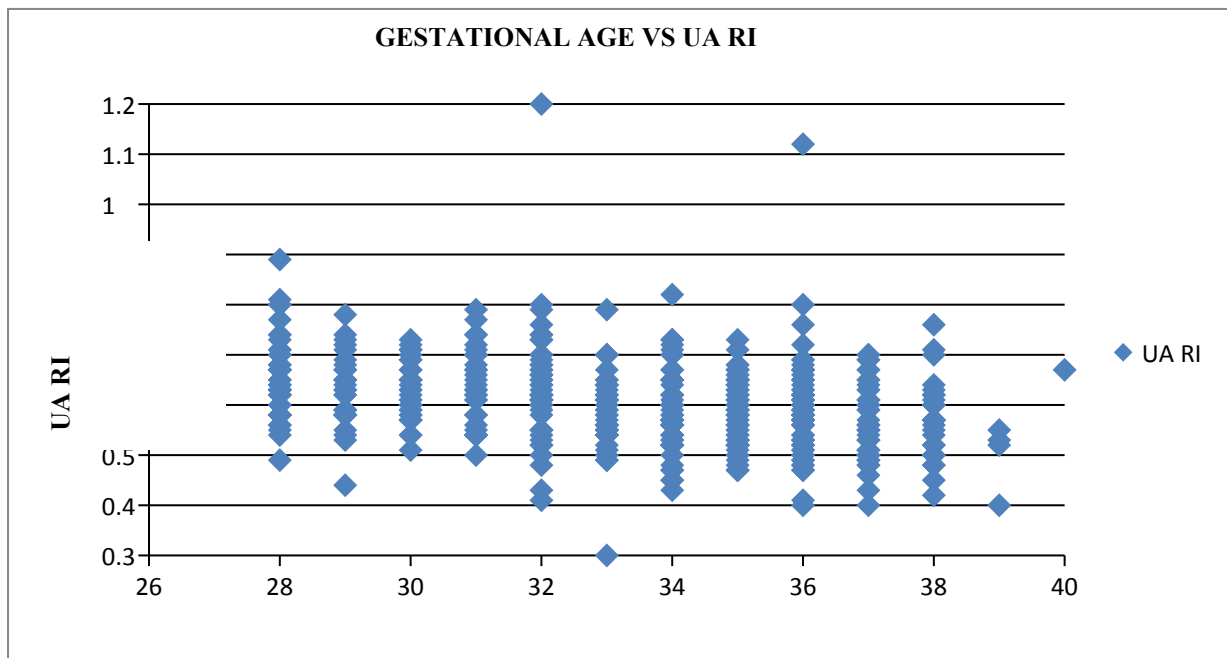
**Figure 3:** CHART SHOWING THE VARIATION OF MIDDLE CEREBRAL ARTERY RESISTIVE INDEX (MCA RI) WITH GESTATIONAL AGE



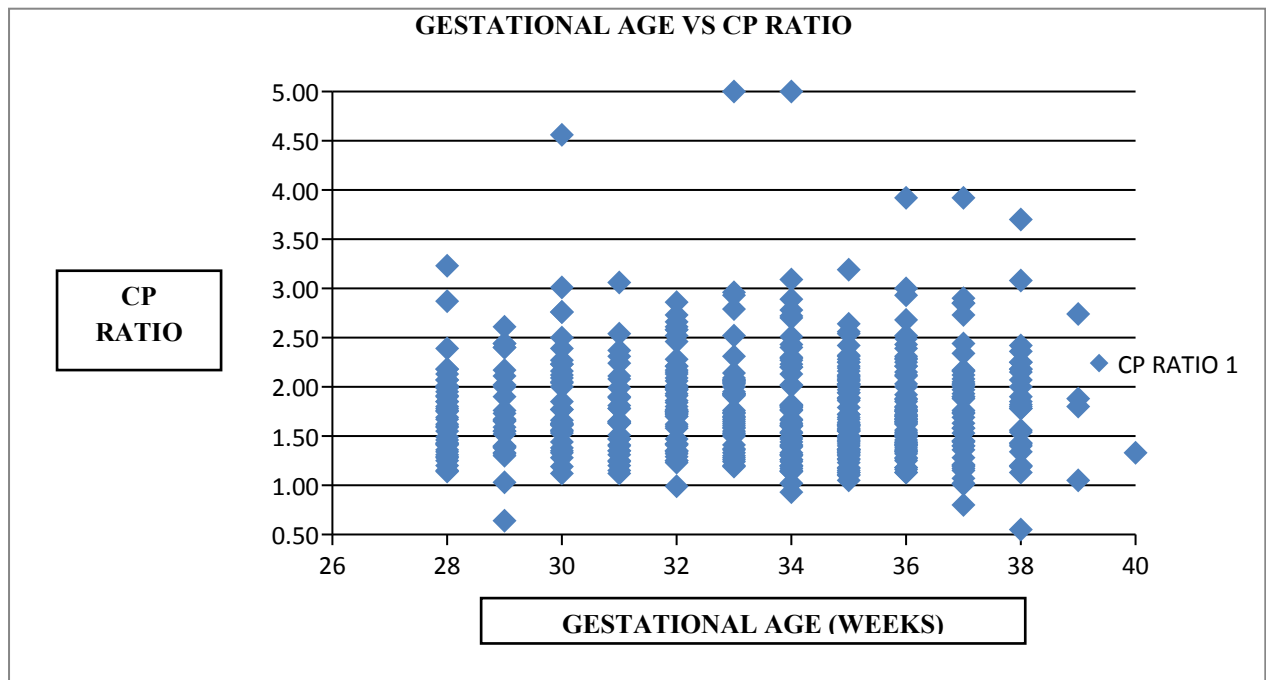
**Figure 4:** CHART SHOWING THE VARIATION OF MIDDLE CEREBRAL ARTERY PULSATILITY INDEX (MCA PI) WITH GESTATIONAL AGE



**Figure 5:** CHART SHOWING THE VARIATION OF UMBILICAL ARTERY PULSATILITY INDEX (UA PI) WITH GESTATIONAL AGE



**Figure 6:** CHART SHOWING VARIATION OF UMBILICAL ARTERY RESISTIVE INDEX (UA RI) WITH GESTATIONAL AGE.



**Figure 7:** CHART SHOWING VARIATION OF GESTATIONAL AGE WITH CEREBROPLACENTAL

#### IV. Discussion

Doppler velocimetry of umbilical artery and middle cerebral artery form an indispensable part of routine obstetric care. Using these indices, adverse uteroplacental and fetal circulatory changes occurring in conditions like fetal growth restriction or fetal anemia can be predicted and thus can help in timely management of these conditions.

##### Middle cerebral artery Doppler indices

These act as indicators of fetal adaptive response to abnormal placental changes. Redistribution of blood to brains known as brain sparing effect occurs due to cerebral vasodilatation. Normally these indices change throughout normal pregnancy. Previous studies done on MCA PI and RI by Ebbing et al.,<sup>1</sup> Mari et al.,<sup>2</sup>Tarzamni et al.,<sup>3</sup> have shown findings similar to ours for MCA PI and RI likely due to increased requirement of brain during late pregnancy. A moderate positive correlation of middle cerebral artery PI and RI with gestational age till 30 weeks followed by a negative correlation with gestation age after 30 weeks was found which is again similar to previous studies<sup>1,2,3</sup>

Our study has shown a negative correlation of MCA PI and RI with gestational age which is similar to the previous studies.<sup>1,2,3</sup> The slight variations in MCA PI and RI value ranges in our study from the previous studies may be due to a different subset of population, socioeconomic status, demographic indices, and statistical methods. A positive correlation was noted between MCA PI and RI in our study which is similar to the study done by Tarzamni et al.<sup>3</sup>

##### Umbilical artery Doppler indices

Umbilical artery Doppler indices indicate the status of uteroplacental circulation and help in prediction of growth restriction. Reduced liquor, cord accidents, poor perinatal outcome can all result due to uteroplacental insufficiency. Also, hypertensive disorders in mother during pregnancy can be attributed to deranged uteroplacental circulation. According to previous studies by Acharya et al.,<sup>4</sup> Harneet et al.,<sup>5</sup> and Kurmanavicius et al.<sup>6</sup>, a gradual fall of umbilical artery RI and PI is seen over advancing gestational ages as also in our study.

Minor variations from previous studies may be due to difference in demographics and sample size of populations.

### **Cerebroplacental ratio (CP ratio)**

This ratio is a combined parameter of middle cerebral artery and umbilical artery PI and is free from observer variations. CP ratio depicts the degree of redistribution of blood to cerebral circulation. A strong correlation has been found between intra uterine growth restriction and reduced CP ratio. Our study shows a negative correlation of CP ratio with gestational age. This may be due to amount of blood volume required by brain in different gestational age. However, there are few studies exploring the changes of CP ratio with gestational age and thus not much have been pondered upon about the causes of such changes. Our study provides a reference range of CP ratio with gestational age.

## **V. Conclusion**

We would like to recommend the following range of normal Doppler parameters in 28-40 weeks of gestational age in eastern population of India:

- Middle cerebral artery (MCA)  
3. Pulsatility Index (PI): 1.62±0.42  
4. Resistive Index (RI): 0.78±0.12
- Umbilical artery (UA)  
3. Pulsatility Index (PI): 0.94±0.23  
4. Resistive Index (RI): 0.60±0.09
- Cerebroplacental ratio (CP ratio) : 1.80±0.57

### **Strength of the study**

1. This study is a longitudinal observation study. Previous studies are either cross sectional studies, or if longitudinal, are of lower sample sizes.
2. To the best of our knowledge, no such study Doppler study in normal gestation has been conducted for the eastern Indian population.
3. Our study population is of varied culture and socioeconomic status; hence, it could represent the general population.
4. In our study, we have proposed a reference curve for CP ratio, which has been described by very few studies.

### **Limitations of the study**

1. The study was done in a single center which could have affected the results.
2. The study suffers from inherent pitfalls of a single investigator observational study.
3. If time permitted more patients could have been included.

## **VI. Conclusion**

A definite pattern can be recognized in the trends of Doppler indices changes in umbilical and middle cerebral arteries from our study. The middle cerebral artery RI and PI follow a characteristic curve and so does CP ratio, likely due to changes in blood requirements in fetal cerebral circulation. The umbilical artery PI and RI show decline due to decrease in resistance as pregnancy advances. Our study can provide a baseline for Doppler indices in obstetric care and help in recognition of abnormal values and predicting high risk cases, especially in people of eastern parts of India. Nevertheless, we would be continuing our study for a greater sample size and also include other Doppler parameters for predicting adverse fetal condition at an earlier stage so that they can be managed efficiently leading to better obstetric care.

### **Conflicts of interest**

None to declare

## **References**

- [1] Ebbing C., Rasmussen S., Kiserud T. Middle Cerebral Artery Blood Flow Velocities And Pulsatility Index And The Cerebroplacental Pulsatility Ratio: Longitudinal Reference Ranges And Terms For Serial Measurements. *Ultrasound Obstet Gynecol.* 2007;30(3):287–296. [PubMed] [Google Scholar]
- [2] Mari G., Deter R.L. Middle Cerebral Artery Flow Velocity Waveforms In Normal And Small-For-Gestational-Age Fetuses. *Am J Obstet Gynecol.* 1992;166(4):1262–1270. [PubMed] [Google Scholar]
- [3] Tarzamani M.K., Nezami N., Sobhani N., Eshraghi N., Tarzamani M., Talebi Y. Nomograms Of Iranian Fetal Middle Cerebral Artery Doppler Waveforms And Uniformity Of Their Pattern With Other Populations' Nomograms. *Bmc Pregnancy Childbirth.* 2008;8:50. [Pmc Free Article] [PubMed] [Google Scholar]
- [4] Acharya G., Wilsgaard T., Berntsen G.K., Maltau J.M., Kiserud T. Reference Ranges For Serial Measurements Of Umbilical Artery Doppler Indices In The Second Half Of Pregnancy. *Am J Obstet Gynecol.* 2005;192(3):937–944. [PubMed] [Google Scholar]

- [5] Harneet N., Kapila A., Kaur M.M. Cerebral And Umbilical Arterial Blood Flow Velocity In Normal And Growth Retarded Pregnancy. *J ObstetGynecol India*. 2009;59(1):47–52. [Google Scholar]
- [6] Kurmanavicius J., Florio L., Wisser J. Reference Resistance Indices Of The Umbilical, Fetal Middle Cerebral And Uterine Arteries At 24–42 Weeks Of Gestation. *Ultrasound Obstet Gynecol*. 1997;10(2):112–120. [PubMed] [Google Scholar]
- [7] Tarzamni M.K., Nezami N., Gatreh-Samani F., Vahedinia S., Tarzamni M. Doppler Waveform Indices Of Fetal Middle Cerebral Artery In Normal 20 To 40 Weeks Pregnancies. *Arch Iran Med*. 2009;12(1):29–34. [PubMed] [Google Scholar]
- [8] Srikumar S, Debnath J, Ravikumar R, Bandhu Hc, Maurya Vk. Doppler Indices Of The Umbilical And Fetal Middle Cerebral Artery At 18-40 Weeks Of Normal Gestation: A Pilot Study. *Med J Armed Forces India*. 2017 Jul;73(3):232-241. Doi: 10.1016/J.Mjafi.2016.12.008. Epub 2017 Jan 17. Pmid: 28790780; Pmcid: Pmc5533518.
- [9] Maulik D., Mundy D., Heitmann E., Maulik D. Umbilical Artery Doppler In The Assessment Of Fetal Growth Restriction. *Clin Perinatol*. 2011;38(1):65–82. [PubMed] [Google Scholar]
- [10] Mari G., Deter R.L. Middle Cerebral Artery Flow Velocity Waveforms In Normal And Small-For-Gestational-Age Fetuses. *Am J Obstet Gynecol*. 1992;166(4):1262–1270. [PubMed] [Google Scholar]
- [11] Dubiel M., Breborowicz G.H., Marsal K., Gudmundsson S. Fetal Adrenal And Middle Cerebral Artery Doppler Velocimetry In High-Risk Pregnancy. *Ultrasound Obstet Gynecol*. 2000;16(5):414–418. [PubMed] [Google Scholar]
- [12] Signore C., Freeman R.K., Spong C.Y. Antenatal Testing-A Reevaluation: Executive Summary Of A Eunice Kennedy Shriver National Institute Of Child Health And Human Development Workshop. *Obstet Gynecol*. 2009;113(3):687–701. [Pmc Free Article] [PubMed] [Google Scholar]
- [13] Fitzgerald D., Drumm J. Non-Invasive Measurement Of Human Fetal Circulation Using Ultrasound: A New Method. *Br Med J*. 1977;2(6100):1450. [Pmc Free Article] [PubMed] [Google Scholar]
- [14] Komwilaisak R., Saksiriwuttho P., Ratanasiri T., Kleebkaow P., Seejorn K. Pulsatility Index Of The Middle Cerebral Artery In Normal Fetuses. *J Med Assoc Thai*. 2004;87(Suppl 3):S34–S37. [PubMed] [Google Scholar]
- [15] Shah N.S., Nandita M., Verma R.N., Desai V.A. Umbilical And Cerebral Arterial Flow Velocity Waveforms And Neonatal Outcome In High Risk Pregnancy. *J ObstetGynecol India*. 2007;57(3):216–220. [Google Scholar]