

DOI: <http://dx.doi.org/10.18203/2320-1770.ijrcog20201810>

Original Research Article

## The efficacy of doppler indices in predicting the neonatal outcome in term preeclamptic women with intrauterine growth restriction: an observational study in a tertiary care centre

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**Received:** 02 March 2020

**Accepted:** 01 April 2020

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### ABSTRACT

**Background:** Doppler flow velocimetry of the umbilical and fetal cerebral circulation is a non-invasive modality used to access the fetal well-being. Doppler is comparatively more specific and is potentially a useful tool in predicting adverse perinatal outcome in high risk cases. Objectives of this study were to evaluate the efficacy of Middle cerebral artery pulsatility index (MCA-PI), umbilical artery pulsatility index (UA-PI) and cerebroplacental ratio (CPR) doppler indices in assessment of fetal well-being. To document neonatal outcome in preeclamptic women with doppler changes.

**Methods:** A retrospective observational study of term preeclamptic women with clinical IUGR admitting in labour room of RLJ Hospital from January 2019 to December 2019. All these women underwent Doppler study and were followed up till delivery.

**Results:** A total 89 term preeclamptic women, 47.19% women had normal delivery, 52.81% lower segment caesarean section. 74.16 % delivered babies required NICU (neonatal ICU) care, 51.69 % babies had a longer duration of NICU care (more than 5 days). The perinatal complications like respiratory distress 8.99% low birth weight 39.33%, meconium stained 10.11%, still born 4.49% and perinatal asphyxia (6.06%). Women with abnormal MCA-PI 46.07% of cases, UA-PI in 40.45% and CPR 57.30%.

**Conclusions:** It was observed that all three parameters CPR, MCA-PI and UA-PI when taken into account together are good utilities in predicting perinatal outcome.

**Keywords:** Doppler indices, Intrauterine growth restriction

### INTRODUCTION

Pregnancy induced hypertension is a major cause of maternal and perinatal morbidity and mortality in developing countries. It is due to the abnormal placental formation, which involves the abnormal trophoblast invasion of spiral arteries resulting in an increase in vascular resistance in the uteroplacental circulation. This process would lead to intrauterine growth restriction (IUGR) if timely intervention does not occur.<sup>1</sup>

When there is placental insufficiency, the fetal circulation undergoes numerous changes, ending in brain sparing effect. Brain sparing is characterised by redistribution of blood flow to organs having more priority like the brain, heart and adrenals at the expense of other organs such as spleen, kidney and peripheral circulation.<sup>2</sup>

Fetal hypoxia amounts a major cause of high perinatal morbidity and mortality rates. It could lead to various neurodevelopmental disabilities, oscillating from

difficulties in school to dyslexia, attention deficit hyperactivity disorder (ADHD), also vision or hearing impairment, mental disorders, including cerebral palsy.<sup>3</sup>

Doppler flow velocimetry of the umbilical and fetal cerebral circulation is a non-invasive modality used to access the fetal well-being. Doppler is comparatively more specific and is potentially a useful tool in predicting adverse perinatal outcome in high risk cases.

Cerebroplacental (CP) ratio has already been very established predictor adverse pregnancy outcome.<sup>2</sup> The Cerebroplacental ratio evaluation detects and the fetal response to oxygen deficiency in utero is evaluated. Nonetheless, the values of MCA RI should remain higher than umbilical artery resistance ratio (UA RI) values, which implicates that Cerebroplacental ratio, being the ratio of MCA RI to UA RI, should be higher than 1-1.1 in uncomplicated pregnancies.<sup>4</sup>

Long-term studies have shown that children with brain sparing have lower IQ scores, impaired cognitive function, attention deficit, and greater difficulties at school.<sup>3</sup>

Hence an attempt is made to evaluate the efficacy of these doppler indices- Middle cerebral artery pulsatility index (MCA-PI) umbilical artery pulsatility index (UA-PI) and cerebroplacental ratio (CPR) in term preeclamptic women and fetal outcome is observed.

**METHODS**

A retrospective observational study of term preeclamptic women was conducted within a period of January 2019-December 2019 in a tertiary care centre, in the department of obstetrics and gynecology. A total of 89 singleton term preeclamptic women with IUGR who were willing to get admitted in the Labour room of RLJ Hospital were included in the study. Gestational age was calculated from last menstrual period and if that was not clear, fetal biometry done in the first or early second trimester scan was taken in to consideration. Pregnancies with multiple gestation, pregnancy complicated with other medical disorders, Intrauterine fetal demise, women who refused to take part in the study was excluded.

After the routine systemic examination and obstetric examination, the blood pressure and urine albumin of the women getting admitted were examined. The routine obstetric scan was done to know the fetal biophysical profile and doppler indices which are MCA-PI, UA-PI and CPR was done. These values were considered abnormal when they would lie below the 5th percentile and above the 95th centile. Perinatal outcome was documented. The adverse outcomes like low birth weight, meconium stained liquor, respiratory distress syndrome, perinatal asphyxia, still born, small for gestational age, babies requiring NICU admission for more than 5 days were noted down.

**Statistical analysis**

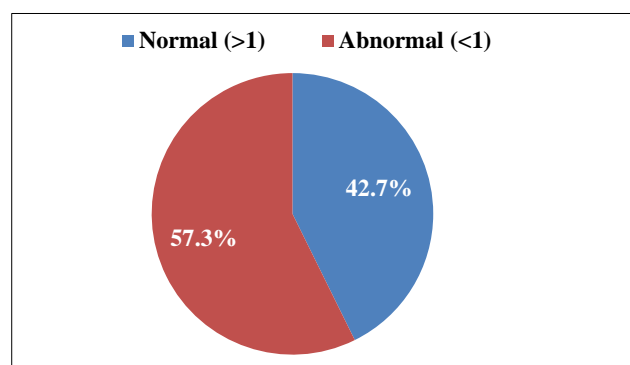
Statistical analysis was made using IBM SPSS version 22. Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables. Non normally distributed quantitative variables were summarized by median and interquartile range (IQR). Data was also represented using appropriate diagrams like bar diagram, pie diagram and box plots. All quantitative variables were checked for normal distribution within each category of explanatory variable by using visual inspection of histograms and normality Q-Q plots. Shapiro-wilk test was also conducted to assess normal distribution. Shapiro-wilk test p value of >0.05 was considered as normal distribution. The sensitivity, specificity, predictive values and diagnostic accuracy of the screening test along with their 95% CI were presented. Reliability of the screening test was assessed by kappa statistic along with its 95% CI and p value.

**RESULTS**

Out of the 89-study population, the mean of age was 25.13±4.33 years in the study population, minimum age was 18 years and maximum age was 36 years. Primigravida was found to be prevalent around 44% of study population. The mean of gestational age was 38.54±1.11 weeks in the study population, minimum gestational age was 37 weeks and maximum age was 41 weeks (Table 1). The mean of systolic blood pressure was 156.79±13.78, and the diastolic blood pressure was 101.06±9.18 in the study population.

**Table 1: Descriptive analysis of gestational age (in weeks) in study population (N=89).**

Parameter	Mean±SD	Minimum	Maximum
Gestational age (in weeks)	38.54±1.11	37.0	41.0



**Figure 1: Cp ratio in the study population (N=89).**

Among the study population 38 (42.7%) had normal cp ratio and remaining 51 (57.3%) participants had abnormal cp ratio, 48 (53.93%) had normal MCA value and remaining 41 (46.07%) participants had abnormal MCA

value, and 53 (59.55%) had normal umbilical arteries and remaining 36 (40.45%) participants had abnormal umbilical arteries (Table 2 and Figure 1).

**Table 2: Descriptive analysis of all the doppler indices (CPR+MCA-PI+UA-PI) in the study population (N=89).**

Cp ratio	Frequency	Percentages
Normal (>1)	38	42.70%
Abnormal (<1)	51	57.30%
<b>MCA-PI value</b>		
Normal	48	53.93%
Abnormal	41	46.07%
<b>UA-PI</b>		
Normal	53	59.55%
Abnormal	36	40.45%

**Table 3: Descriptive analysis of mode of delivery in study population (N=89).**

Parameters	Frequency	Percentage
Normal delivery	42	47.19%
Induced vaginal delivery	35	83.33%
Caesarean delivery	47	52.80%

Among the study population, 69 (77.53%) babies were admitted in NICU. Few required prolonged NICU admission (more than five days) and was documented (as shown in Table 3).

Among the study population, 46 (66.67%) babies were admitted in NICU more than 5 days and 23 (33.3%) babies were admitted less than 5 days in NICU (Table 4).

**Table 4: Descriptive analysis of NICU admission in the study population (N=69).**

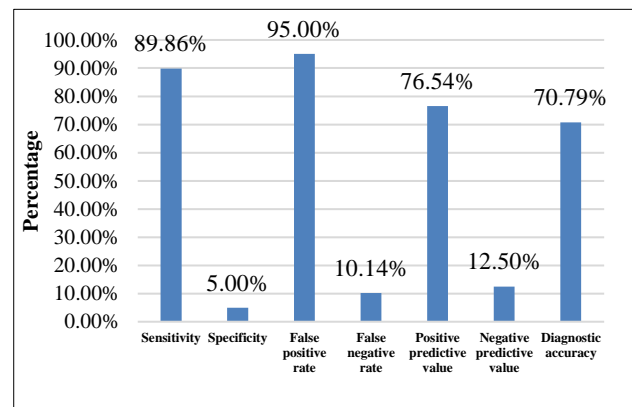
NICU admission	Frequency	Percentages
>5 days	46	66.67%
<5 days	23	33.33%

**Table 5: Descriptive analysis of perinatal complications in the study population (N=89).**

Perinatal complications	Frequency	Percentages
Low birth weight	35	39.33%
Meconium stained	9	10.11%
Respiratory distress	8	8.99%
Respiratory distress+ low birth weight	7	7.87%
Perinatal asphyxia	4	4.49%
Still born	4	4.49%
Low birth weight+ perinatal asphyxia	1	1.12%
Respiratory distress+ low birth weight	1	1.12%
Small for gestational age	1	1.12%

Among the study population, majority of participants perinatal complications 35 (39.33%) had low birth weight 35 (39.33%), 9 (10.11%) participants had Meconium stained (Table 5).

Out of 69 NICU admitted people, 37 (53.62%) participants had abnormal Cp ratio and remaining 32 (46.38%) participants had normal Cp ratio. The difference in the proportion of Cp ratio between NICU was statistically significant (p value 0.022). 37 (53.62%) participants had abnormal MCA and remaining 32 (46.38%) participants had normal MCA. The difference in the proportion of MCA value between NICU was statistically significant (p value 0.008). (table 16) Out of 69 NICU admitted people, 24 (34.78%) participants had abnormal umbilical arteries and remaining 45 (65.22%) participants had normal umbilical arteries. The difference in the proportion of umbilical arteries between NICU was statistically significant (p value 0.043). 62 (89.86%) participants had abnormal combination (Cp ratio, MCA, umbilical arteries) and remaining 7 (10.14%) participants had normal combination (Cp ratio, MCA, umbilical arteries). The difference in the proportion of Combination (Cp Ratio, MCA, umbilical arteries) between NICU was statistically not significant (p value 0.479) (Table 6).



**Figure 2: Predictive validity of combination (Cp ratio, MCA-PI, UA-PI) in predicting NICU (N=89).**

The Cp ratio had sensitivity of 63.77% (95% CI 51.31% to 75.01%) in predicting NICU admission. Specificity was 65% (95% CI 40.78% to 84.61%), false positive rate was 35% (95% CI 15.39% to 59.22%), false negative rate was 36.23% (95% CI 24.99% to 48.69%), positive predictive value was 86.27% (95% CI 73.74% to 94.3%), negative predictive value was 34.21% (95% CI 19.63% to 51.35%), and the total diagnostic accuracy was 64.04% (95% CI 53.18% to 73.95%). The MCA had sensitivity of 53.62% (95% CI 41.2% to 65.72%) in predicting NICU admission. Specificity was 80% (95% CI 56.34% to 94.27%), false positive rate was 20% (95% CI 5.73% to 43.66%), false negative rate was 46.38% (95% CI 34.28% to 58.8%), positive predictive value was 90.24% (95% CI 76.87% to 97.28%), negative predictive value was 33.33% (95% CI 20.4% to 48.41%), and the total diagnostic accuracy was 59.55% (95% CI 48.62% to

69.83%). The umbilical arteries had sensitivity of 34.78% (95% CI 23.71% to 47.21%) in predicting NICU admission. Specificity was 40% (95% CI 19.12% to 63.95%), false positive rate was 60% (95% CI 36.05% to 80.88%), false negative rate was 65.22% (95% CI 52.79% to 76.29%), positive predictive value was 66.67% (95% CI 49.03% to 81.44%), negative predictive

value was 15.09% (95% CI 6.75% to 27.59%), and the total diagnostic accuracy was 35.96% (95% CI 26.05% to 46.82%) (Table 7).

The combination (Cp ratio, MCA, umbilical arteries) had sensitivity of 89.86% (95% CI 80.21% to 95.82%) in predicting NICU admission.

**Table 6: Comparison of NICU admission with doppler indices (N=89).**

Cp ratio	NICU		Chi square	p value
	Yes (N=69)	No (N=20)		
Abnormal (<1)	44 (63.77%)	7 (35%)	5.245	0.022
Normal (>1)	25 (36.23%)	13 (65%)		
<b>MCA-PI value</b>				
Abnormal	37 (53.62%)	4 (20%)	7.055	0.008
Normal	32 (46.38%)	16 (80%)		
<b>UA-PI</b>				
Abnormal	24 (34.78%)	12 (60%)	4.093	0.043
Normal	45 (65.22%)	8 (40%)		
<b>Combination (Cp ratio, MCA, umbilical arteries)</b>				
Abnormal	62 (89.86%)	19 (95%)	0.502	0.479
Normal	7 (10.14%)	1 (5%)		

**Table 7: Predictive validity of doppler indices in predicting NICU admission (N=89).**

CPR parameter	Value	95% CI	
		Lower	Upper
Sensitivity	63.77%	51.31%	75.01%
Specificity	65.00%	40.78%	84.61%
Positive predictive value	86.27%	73.74%	94.30%
Negative predictive value	34.21%	19.63%	51.35%
Diagnostic accuracy	64.04%	53.18%	73.95%
<b>MCA-PI parameter</b>			
Sensitivity	53.62%	41.20%	65.72%
Specificity	80.00%	56.34%	94.27%
Positive predictive value	90.24%	76.87%	97.28%
Negative predictive value	33.33%	20.40%	48.41%
Diagnostic accuracy	59.55%	48.62%	69.83%
<b>UA-PI parameter</b>			
Sensitivity	34.78%	23.71%	47.21%
Specificity	40.00%	19.12%	63.95%
Positive predictive value	66.67%	49.03%	81.44%
Negative predictive value	15.09%	6.75%	27.59%
Diagnostic accuracy	35.96%	26.05%	46.82%

**Table 8: Predictive validity of combination (CP ratio, MCA-PI, UA-PI) in predicting NICU (N=89).**

Parameter	Value	95% CI	
		Lower	Upper
Sensitivity	89.86%	80.21%	95.82%
Specificity	5.00%	0.13%	24.87%
Positive predictive value	76.54%	65.82%	85.25%
Negative predictive value	12.50%	0.32%	52.65%
Diagnostic accuracy	70.79%	60.19%	79.95%

Specificity was 5.00% (95% CI 0.13% to 24.87%), false positive rate was 95.00% (95% CI 75.13% to 99.87%), false negative rate was 10.14% (95% CI 4.18% to 19.79%), positive predictive value was 76.54% (95% CI 65.82% to 85.25%), negative predictive value was 12.50% (95% CI 0.32% to 52.65%), and the total diagnostic accuracy was 70.79% (95% CI 60.19% to 79.95%) (Table 8 and Figure 2).

## DISCUSSION

The placental insufficiency that occurs due to preeclampsia leads to improper blood flow in the uterine and umbilical arteries. This inadequate fetal circulation leads to growth restriction in utero. According to a study conducted by Kshirsagar et al, out of 100 women participating, 42% of them had a full-term normal delivery and 25% underwent full term caesarean section. In this study, 42 women underwent normal delivery accounting to 47.19% of population.<sup>5</sup> Out of them, 35 women were induced accounting to about 83.33%. The rest of them underwent emergency Caesarean section. 4 still born was documented, and all the 4 cases were referred from nearby local Hospitals.

### *Middle cerebral artery doppler*

The middle cerebral artery along with ductus venosus depict how the fetus is coping. Reduced MCA PI and MCA/UA PI which is the cerebroplacental ratio is the early signs of fetal hypoxemia in SGA fetuses. The brain sparing effect can develop in 2 scenarios: i) in early onset Small for gestational age (before 32 weeks). Here umbilical artery (UA) is already abnormal, there is worsening of placental circulation, (b) in late onset small for gestational age (SGA) (after 32 weeks) where UA is normal because fetal metabolic needs are greater than placental capacity even in absence of placental insufficiency. It is seen that predictive ability of adverse fetal/neonatal outcome is higher in the later scenario. Accordingly, the development of brain sparing effect should be considered for time to deliver in later onset-SGA.<sup>6</sup> According to a study by Lopez-Mendez et al, in 102 study population middle cerebral artery had better sensitivity, specificity, and positive predictive value than umbilical artery the similar result was seen in this study as well.

According to Kshirsagar et al, the middle cerebral artery pulsatility index had maximum sensitivity and negative predictive value for predicting poor perinatal outcome.<sup>5</sup> In this study when compared to umbilical artery pulsatility index the sensitivity and negative predictive value was higher in predicting poor perinatal outcome. Lakhar et al, in a population of 58 with severe preeclampsia complicated with intrauterine growth restriction, there was a documentation of 12 perinatal death and 5 still borns. The MCA pulsatility index was most specific with 90.9% and umbilical artery was more sensitive in predicting the adverse effect of neonates.<sup>7</sup> This study

supports this studies results as this study also showed MCA-PI being specific and sensitive to predict adverse perinatal outcome when compared with umbilical artery PI.

### *Umbilical artery doppler*

Umbilical artery velocimetry is related with hemodynamic changes which occur in the fetoplacental circulation. The impedance in the umbilical artery decreases with an increase in tertiary stem villi and arterial channels leading to the formation of the fetoplacental compartment. After 15 weeks of gestation, umbilical artery resistance is showed to decline and the diastolic component appears in the waveform during early second trimester.<sup>8</sup> In Kshirsagar et al, the umbilical artery resistance index had the maximum specificity and positive predictive value for predicting perinatal outcome.<sup>5</sup> In this study, however it had the least specificity and positive predictive value when compared to the others in predicting perinatal morbidity and mortality.

In a study conducted by Adekanmi et al, concluded that comparatively uterine artery pulsatility index is the best predictor of preeclampsia and hence poor perinatal outcome when compared to umbilical artery.<sup>9</sup> This study was in contrast to the findings documented in this study could be due to more of study population being preterm and this study was more in favors of term gestation. In a study conducted by Borges KJJ et al, 90 pregnancy induced hypertension population with gestational age greater than 35 weeks was considered and they noticed that with increasing value of umbilical artery resistance index there was greater risk of low birth weight seen. They also went on to document that marginal cord insertion showed increased UA- resistance index.<sup>10</sup>

Similar result was seen in this study, low birth weight accounted to about 39.33% of the babies born which is the highest when compared to the other morbidities noted in this study.

### *Cerebroplacental ratio (CPR)*

According to a study conducted by Adiga et al, of 100 women with pregnancy induced hypertension, specificity and positive predictive value of Cp ratio was higher when compared to cerebrouterine ratio in the prediction of perinatal adverse outcome, also gestational age at delivery was documented as 35.47 weeks $\pm$ 2.752 weeks.<sup>2</sup> In this study, Cp ratio showed the maximum sensitivity, and diagnostic accuracy when compared to others in predicting morbidity and mortality.

## CONCLUSION

In this study, when we compared the doppler indices individually, it was found that MCA-PI when compared to UA-PI the sensitivity and negative predictive value

was higher but lesser than Cp ratio and negative predictive value almost similar to Cp ratio, but it had the highest specificity and positive predictive value among all the three and had in predicting poor perinatal outcome. However, the diagnostic accuracy of MCA-PI was found to be also more than UA-PI and lesser than Cp ratio. Hence, after contemplating all these factors we conclude that it would be better to consider all the three doppler indices to predict the perinatal mortality and morbidity to overcome individual shortcomings. As it is a non-invasive procedure it is a useful tool for evaluating fetal well-being and predicting perinatal outcome.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: Not required*

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**Cite this article as:** Raj K, Sheela SR. The efficacy of doppler indices in predicting the neonatal outcome in term preeclamptic women with intrauterine growth restriction: an observational study in a tertiary care centre. Int J Reprod Contracept Obstet Gynecol 2020;9:2087-92.