

ROLE OF DOPPLER INDICES IN THE PREDICTION OF ADVERSE PERINATAL OUTCOME IN PREECLAMPSIA

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ABSTRACT

Objective: To determine diagnostic accuracy of systolic/diastolic ratio and cerebro-placental index in predicting adverse perinatal outcome among patients in preeclampsia.

Study Design: Cross-sectional validation study.

Place and Duration of Study: Department of Obstetrics and Gynaecology, Pak Emirates Military Hospital, Rawalpindi, from Jun to Dec 2017.

Methodology: A total of 191 patients with preeclampsia were included. Doppler ultrasound (including doppler wave forms obtained from free floating portion of umbilical artery and doppler waveform from middle cerebral artery at the level of circle of Willis) examination was done after gestational age 30 weeks and Doppler study repeated at 2-4 weeks interval depending on severity of preeclampsia and abnormalities of waveform. Cases were followed and results of last Doppler examination within 10 days of delivery were considered and perinatal outcome noted.

Results: The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of systolic/diastolic ratio in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard was 82.35%, 86.52%, 87.50%, 81.05% and 84.29% respectively. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of cerebro-placental index in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard was 78.67%, 92.24%, 86.76%, 86.99% and 86.91% respectively.

Conclusion: The diagnostic accuracy of systolic/diastolic ratio, cerebro-placental index in predicting adverse perinatal outcome among patients in preeclampsia is quite high.

Keywords: Adverse perinatal outcome, Doppler ultrasound, Preeclampsia.

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INTRODUCTION

Hypertensive disorders are associated with 7-10% of all the pregnancies. They can be classified into five types according to the Working Group of National High Blood Pressure Education Programme [NHBPEP] and American College of Obstetricians and Gynaecologists (ACOG)¹. Preeclampsia is a major cause of maternal and perinatal morbidity and mortality². Preeclampsia is responsible for 22% of all perinatal mortality³.

Abnormal placentation is underlying pathology in pre-eclampsia and in it trophoblastic invasion of spiral arterioles is impaired and inadequate leading to increase resistance in uteroplacental circulation and decrease perfusion⁴⁻⁶. Preeclampsia is responsible for various adverse outcomes including prematurity, low birth weight, neonatal intensive care, intrauterine foetal death, foetal hypoxia, perinatal death³. Foetal hypoxia activates various responses including variations in heart rate and changes in blood flow to vital organ⁴. These changes in blood flow can be measured by non-

invasive method i.e. Doppler ultrasound velocimetry and help to diagnose in-time foetal compromise so that timely intervention can be taken to decrease foetal morbidity and mortality^{5,6}. The first application of doppler velocimetry in obstetrics was reported by Fitzgerald *et al*⁵.

Doppler velocimetry is a non invasive technology which uses the Doppler principle to analyze the properties of blood flow in vessel of interest⁷. It can detect fetal compromise by detecting changes in blood flow in Umbilical artery (UmA) and Middle cerebral artery (MCA) very earlier than any other antepartum test³. Doppler data combining both umbilical and cerebral velocimetry provide vital information on fetal consequences of the placental abnormalities in hypertensive pregnancies thus can be used as an important tool for making decision in the appropriate timing of intervention for delivery⁷.

Although umbilical arteries are the common vessels assessed by DU, recent studies have shown the efficacy of the middle cerebral artery (MCA) Doppler assessment⁸. Today, with the advancement of pulsed and colour-coded DU combined with better reproduc-

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bility, the MCA has emerged as the vessel of choice in the doppler assessment of fetal intracranial as well as other organs perfusion⁹. Applicability of doppler indices in the diagnosis of abnormalities is possible only when there are reference normal values for each index. Various investigators have described and established gestational age-related reference curves¹⁰.

The blood flow characteristics can be quantified by doppler indices by systolic/diastolic (S/D) ratio= peak systolic velocity/end diastolic velocity, resistance index (RI=peak systolic velocity-end diastolic velocity/peak systolic velocity), cerebroplacental index (CPI=MCA resistance/UmA resistance), pulsatility Index (peak systolic velocity-end diastolic velocity/mean velocity)^{6,7}. Several studies have reported higher sensitivities and specificities for S/D ratio and CPI with umbilical artery velocimetry alone for prediction of the fetal prognosis². One of the study showed that fetuses with UA systolic diastolic (SD) ratio >3 were associated with poor perinatal outcome in 89.65% with sensitivity and specificity of 80% and 82.86% respectively². Fetuses with CPI ≤1 have poor perinatal outcome in 95.74% with higher sensitivity (69.23%) and specificity (93.94%) respectively². In another study 28 (46%) out of 60 patients had abnormal umbilical artery waveform, out of which 18 (30%) had adverse perinatal outcome⁴.

Multiple international and regional studies have been done regarding this aspect of preeclampsia patients delineating those pregnancies at risk of adverse perinatal outcome but no work has been done specifically in this regard in our population. This study would help us in estimating the role of doppler indices in at risk pregnancies of preeclampsia patients and thus would guide us in improving our own management practices

METHODOLOGY

This cross-sectional validation study was conducted at department of Obstetrics and Gynecology, Pak Emirates Military Hospital, Rawalpindi, from June to December 2017. Sample size was calculated by WHO sample size calculator by using the population prevalence proportion of adverse perinatal outcomes in patients of preeclampsia as 30%, sensitivity as 69.23% and specificity as 93.94%².

Final sample size turned out to be 191. Non-probability, purposive sampling was used to gather the sample for the study. All Singleton pregnancies with age between 20-40 years and gestational age ≥30 weeks and Patients with BP ≥ 140/90 mmHg with proteinuria of +1 on dipstick were included in the study. Patients

with multiple gestation or congenital anomalies of fetus or patients with chronic hypertension, diabetes mellitus, renal disease and other chronic conditions were excluded from the study.

After approval by Ethics Committee Pak Emirates Military Hospital (PEMH) Rawalpindi, informed consent was taken from all the patients prior to inclusion in the study. Patients visiting Obstetric OPD of PEMH, admitted to Antenatal Ward, Labour Room were assessed for eligibility criteria and those fulfilling the criteria were included in the study.

Demographic data was collected, detail history was taken and Obstetric examination was performed. Doppler ultrasound (including Doppler waveforms obtained from free floating portion of umbilical artery and Doppler waveform from middle cerebral artery at the level of circle of Willis) examination was done after gestational age 30 weeks and Doppler study repeated at 2-4 weeks interval depending on severity of preeclampsia and abnormalities of waveform^{11,12}. Cases were followed and results of last doppler examination within 10 days of delivery were considered and perinatal outcome noted. All the data was entered in the research performa.

Data was entered and analyzed in SPSS-23. Descriptive statistics such as Mean and Standard Deviation were calculated for quantitative variables like age of patient, gestational age, birth weight of neonate. Frequency and percentages were computed for qualitative variables like perinatal outcome. A 2x2 table was constructed to calculate sensitivity, specificity, PPV, NPV. ROC and likelihood ratio were calculated.

RESULTS

A total of 191 patients with BP ≥ 140/90 mmHg with proteinuria of +1 on dipstick with age ranges from 20-40 years of age with gestational age >30 weeks were included. Age range in this study was from 20-30 years with mean age of 30.01 ± 5.37 years. Mean gestational age was 33.23 ± 41 weeks. Mean birth weight was 2.89 ± 0.89 grams.

SD ratio predicted the adverse perinatal outcome in 96 (50.26%) patients. Actual adverse perinatal outcome was found in 102 (53.40%) patients. In SD ratio positive patients, 84 (True Positive) had adverse perinatal outcome and 12 (False Positive) had no adverse perinatal outcome. Among 95, SD ratio negative patients, 18 (False Negative) had actual adverse perinatal outcome whereas 77 (True Negative) had no adverse perinatal outcome ($p=0.0001$) as shown in table-I. Over-

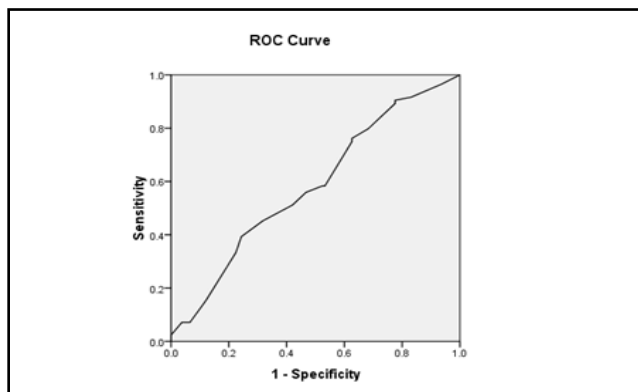
all sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of SD ratio in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard was 82.35%, 86.52%, 87.50%, 81.05% and 84.29% respectively (table-II). ROC curve SD ratio in predicting adverse perinatal outcome among patients in preeclampsia (figure).

Table-I: Diagnostic accuracy of systolic diastolic ratio in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard.

	Adverse Perinatal Outcome		p-value
	Positive	Negative	
Positive result on systolic Diastolic ratio	84 (true positive)	12 (false positive)***	<0.001
Negative result on systolic Diastolic ratio	18 (false negative)**	77 (true negative)****	

Table-II: Diagnostic parameters.

Diagnostic Parameters	p-value
Sensitivity= True Positive/(True Positive +False Negative)	82.35%
Specificity= True Negative / (True Negative +False Positive)	86.52%
Positive Predictive Value= True Positive/(True Positive+ False Positive)	87.50%
Negative Predictive Value= True Negative/(True Negative +False Negative)	81.05%
Diagnostic Accuracy=(True Positive +True Negative)/All Patients	84.25%



Area under the curve = 0.583.

Figure: Systolic diastolic ratio in predicting adverse perinatal outcome among patients in preeclampsia.

CPI predicted the adverse perinatal outcome in 68 (35.60%) patients. Actual adverse perinatal outcome was found in 75 (39.27%) patients. In CPI positive patients, 59 (True Positive) had adverse perinatal outcome and 9 (False Positive) had no adverse perinatal out-

come. Among 123, CPI negative patients, 16 (False Negative) had actual adverse perinatal outcome whereas 107 (True Negative) had no adverse perinatal outcome ($p=0.0001$) as shown in table-III. Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of CPI in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard was 78.67%, 92.24%, 86.76%, 86.99% and 86.91% respectively (table-IV).

Table-III: Diagnostic accuracy of cerebro-placental index in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard.

	Adverse Perinatal Outcome		p-value
	Positive	Negative	
Positive result on cerebro-placental index	59 (true positive)	09 (false positive)	0.0001
Negative result on cerebro-placental index	16 (False negative)	107 (True negative)	

Table-IV: Diagnostic parameters.

Diagnostic Parameters	p-value
Sensitivity= True Positive/(True Positive +False Negative)	78.67%
Specificity= True Negative / (True Negative +False Positive)	92.24%
Positive Predictive Value= True Positive/(True Positive+ False Positive)	86.76%
Negative Predictive Value= True Negative/(True Negative +False Negative)	86.99%
Diagnostic Accuracy=(True Positive +True Negative)/All Patients	86.91%

DISCUSSION

Doppler ultrasound is a non-invasive technique, which can easily be used for evaluation of maternal and fetal hemodynamics. It was first described by Fitzgerald, who used a standard ultrasound device combined with a doppler ultrasound beam¹³. His recordings were analyzed by headphone and allowed him to observe the fetal umbilical arteries. Since then, doppler ultrasound technique has rapidly developed into a quick and easy way to study fetal and maternal circulation.

Doppler ultrasound provides an evaluation of fetal haemodynamics¹⁴. Doppler investigations of the umbilical arteries provide information concerning perfusion circulation, while doppler studies of selected fetal organs are valuable in detecting the haemodynamic rearrangements that occur in response to fetal hypoxia and anaemia. When caused by uteroplacental

dysfunction, the typical progress begins with increased resistance in the umbilical artery, is followed by decreased resistance in the middle cerebral artery, and is completed with the development of abnormal venous waveforms as cardiac function deteriorates. Even though the failure of a fetus to attain or exceed its expected growth potential may result from numerous different pregnancy complications, the final common pathway most often encountered in practice is via uteroplacental insufficiency¹⁵. Doppler ultrasound allows a direct estimation of fetal circulation and placental function¹⁶. The most widely employed indices for arterial flow are the systolic diastolic (S/D) ratio the resistive index (RI) and the pulsatility index (PI)¹⁷.

We conducted this study to determine diagnostic accuracy of SD ratio, CPI in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard. In our study, SD ratio predicted the adverse perinatal outcome in 50.26% patients. Actual adverse perinatal outcome was found in 53.4% patients. In SD ratio positive patients, 84 (True Positive) had adverse perinatal outcome and 12 (False Positive) had no adverse perinatal outcome. Among 95, SD ratio negative patients, 18 (False Negative) had actual adverse perinatal outcome whereas 77 (True Negative) had no adverse perinatal outcome ($p=0.0001$). Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of SD ratio in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard was 82.35%, 86.52%, 87.50%, 81.05% and 84.29% respectively.

CPI predicted the adverse perinatal outcome in 35.60% patients. Actual adverse perinatal outcome was found in 39.27% patients. In CPI positive patients, 59 (True Positive) had adverse perinatal outcome and 9 (False Positive) had no adverse perinatal outcome. Among 123, CPI negative patients, 16 (False Negative) had actual adverse perinatal outcome whereas 107 (True Negative) had no adverse perinatal outcome ($p=0.0001$). Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of CPI in predicting adverse perinatal outcome among patients in preeclampsia, keeping actual adverse perinatal outcome as reference standard was 78.67%, 92.24%, 86.76%, 86.99% & 86.91% respectively.

One of the study showed that fetuses with UA SD ratio >3 were associated with poor perinatal outcome in 89.65% with sensitivity and specificity of 80% and

82.86% respectively². Fetuses with cerebroplacental index (CPI) ≤ 1 have poor perinatal outcome in 95.74% with higher sensitivity (69.23%) and specificity (93.9%) respectively². In another study 28 (46%) out of 60 patients had abnormal umbilical artery waveform, out of which 18 (30%) had adverse perinatal outcome⁴.

Rochelson *et al*¹⁸, had shown that a C/U pulsatility ratio of less than 1.08 had a sensitivity of 68%, specificity 98.4%, positive predictive value 94.4%, negative predictive value 88.8% and diagnostic accuracy 90% for predicting adverse perinatal outcomes in IUGR. Another study¹⁹, using C/U PI ratio of <1.08 found sensitivity of 83.3%, specificity 100%, positive predictive value 100%, negative predictive value 94.3% and diagnostic accuracy 95.6% for predicting adverse perinatal outcomes in IUGR.

CONCLUSION

Diagnostic accuracy of SD ratio, CPI in predicting adverse perinatal outcome among patients in preeclampsia is quite high.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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