Section: Radiodiagnosis

Original Research Article

THE INFLUENCE OF ULTRASOUND DOPPLER AT PRIMARY AND SECONDARY CARE HOSPITALS TO TRIAGE HIGH-RISK MOTHERS FOR POOR FETAL OUTCOME

Balaji Ayyamperumal[1], Harish Giridhar[2], M. Srinivasan[2], Srinivasan[3], A. Priya[4]

[1]Associate Professor, Department of Radiodiagnosis, Thanjavur Medical College, Tamilnadu, India
[2]Assistant Professor, Department of Radiodiagnosis, Thanjavur Medical College, Tamilnadu, India
[3]Professor, Department of Radiodiagnosis, Thanjavur Medical College, Tamilnadu, India
[4]Senior Resident, Department of Radiodiagnosis, Thanjavur Medical College, Tamilnadu, India

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Corresponding Author:
Dr. A.Srinivasan,
Email: balajianaesthetist@gmail.com

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Abstract

Background: Ultrasound Doppler has a major role in the care and management of obstetric patients. The study evaluates the role of Doppler ultrasonogram role in high-risk pregnant mothers, compares the diagnostic performance of fetal vessels, and determines poor fetal prognosis using the ROC curve. **Materials and Methods:** This prospective observational study was conducted at Thanjavur Medical College from January 2021 to June 2022. Patients were followed up till labour and data regarding fetal outcome was collected. Fetal outcome parameters like APGAR score, neonatal death, Complications in the neonatal period, duration of NICU stay and birth weight were collected. complications observed in the neonatal period include respiratory distress syndrome, sepsis, hypoxic-ischemic encephalopathy, and intracerebral and intraventricular haemorrhage. **Result:** Of the 65 patients, the majority belonged to the age group of 23-27 years (35.4%), and age was not significantly associated with poor fetal outcomes. Among high-risk factors, 51(78.5%) antenatal women had gestational hypertension and preeclampsia, 8 (12.3%) antenatal women had gestational diabetes, and 28 (43.1%) had anaemia. A study of flow patterns in the aortic isthmus and ductus venosus showed flow reversal in 6(9%) and was significantly associated with poor perinatal outcomes. Thirty-five had abnormal Doppler values, 27 had poor perinatal outcomes, and 36.9% had mild placental insufficiency or stage 1 FGR. 51% had a caesarean section, while 49% had a normal delivery. **Conclusion:** Increased pulsatility and resistive indices in umbilical arteries are significantly associated with poor perinatal outcomes. These values can be used to screen high-risk women and establish an institutional protocol for managing fetal growth restriction (FGR) in primary and secondary level hospitals.

INTRODUCTION

Obstetric ultrasound has become an inevitable screening tool nowadays in treating obstetric patients. Employing the right techniques to identify fetuses at risk and timely intervention can decrease fetal morbidity and death. The fetus receives nutrients and oxygen from the uteroplacental and fetal circulation, which is crucial for its growth and development. Doppler ultrasound offers a window to evaluate this fetoplacental circulation and infer fetal health.[1]

The umbilical artery, middle cerebral artery, umbilical vein, aortic isthmus, and ductus venosus are among the arteries sampled to evaluate the fetoplacental unit and used to assess the growth-restricted fetus in the third trimester. Fetal hypoxia and acidosis indicate that the umbilical and middle cerebral arteries' doppler indices are abnormal. Early identification of fetal hypoxia can direct the obstetrician towards prompt management, significantly lowering perinatal death and morbidity. Doppler parameter changes occur in a logical order. Early fetal hypoxia is when the umbilical and middle cerebral arteries changes.[2] The aortic isthmus and ductus venosus undergo changes, which point to advanced foetal hypoxia and severe acidosis. If prompt intervention is not taken, the end of the spectrum is pulsatile flow seen in the umbilical vein, which is followed by decelerations in Cardiotopography and fetal death. Diagnosis of Fetal growth restriction (FGR) and high-risk FGR triage are crucial but remain a significant barrier in

peripheral obstetric care.[3,4] Therefore, the present study aimed to assess the role of the Doppler - ultrasonogram in high-risk pregnant mothers and to compare the diagnostic performance of the foetal Umbilical artery, Middle cerebral artery, Aortic isthmus and Ductus venosus. In addition, we have determined the cut-off values for poor fetal prognosis using the ROC curve for the study population at Thanjavur Medical College.

MATERIALS AND METHODS

This prospective observational study was conducted at Thanjavur Medical College from January 2021 to June 2022. The study was performed after obtaining Institutional Ethics Committee approval, and institutional informed consent guidelines were observed.

Inclusion Criteria

18 to 40 years of age, antenatal women with Gestational age ranging between 32 to 39 weeks of pregnancy, including high-risk factors like Gestational hypertension and preeclampsia, Gestational diabetes, and anaemia who were referred for Doppler ultrasonogram were included.

Exclusion Criteria

Multiple gestation and gestation with sonographically detected congenital anomalies were excluded.

Relevant entries in the proforma for each subject were made after reviewing the case sheet & previous medical records. The final population enrolled in this study was composed of 65 patients. The study used Esaote Mylab Six colour Doppler machine employing a 3-5–MHz convex transducer. Gestational age was calculated from the last menstrual period and first-trimester ultrasound reference values. The obstetric examination includes the assessment of fetal biometry as per standard protocol, colour Doppler ultrasonogram assessment of fetal vessels like the Umbilical artery, Middle cerebral artery, Aortic isthmus, Ductus venosus and Umbilical vein.[5,6]

Any alteration in waveform pattern like reduced, absent and reversed end diastolic flow was observed and recorded for the Umbilical artery. Spectral waveform Doppler parameters like the Pulsatility index and Resistance index were calculated for both the Umbilical and Middle cerebral arteries. Using spectral waveform, the presence of antegrade and retrograde flow in diastole was recorded for vessels like the Aortic isthmus and Ductus venosus. For the Umbilical vein, the presence of pulsatile flow was recorded. Patients were classified as those having fetal growth restriction or those without fetal growth restriction.

Collection of Fetal Outcome Parameters

Patients were followed up till labour and data regarding fetal outcome was collected. Of the 65 antenatal women, 6 had intrauterine death. The rest of the 59 women were followed up, and fetal outcome parameters like APGAR score, neonatal death, Complications in the neonatal period, duration of NICU stay and Birth weight were collected. Complications observed in the neonatal period include respiratory distress syndrome, sepsis, hypoxic-ischemic encephalopathy, and intracerebral and intraventricular haemorrhage.

The outcome was classified as good and poor outcome based on parameters like intrauterine death, neonatal death, APGAR score < 6 at 5 minutes, neonatal complications, and prolonged duration of NICU stay (more than 15 days) are taken as poor outcome. Various Doppler indices were compared with fetal outcomes, and conclusions were derived.

Statistical Analysis

The collected data from all the enrolled patients were analysed with IBM.SPSS statistics software 23.0 Version. Descriptive statistics, frequency analysis and percentage analysis, were used for categorical variables, and the mean & Standard Deviation were used for continuous variables. The unpaired sample t-test was used to find the significant difference between the bivariate samples in independent groups. The Chi-Square test was used to find the significance of categorical data. The probability value of .05 is considered a significant level in both statistical tools.

RESULTS

Of the 65 patients, the majority belonged to the age group of 23-27 years (35.4%), and age was not significantly associated with poor fetal outcomes. Most of the antenatal women were primi gravida (61.5%) [Figure 1].

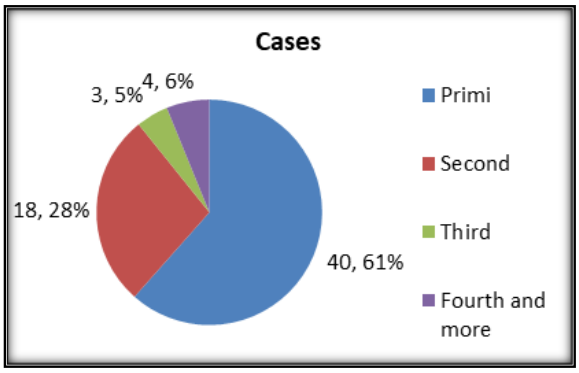

Figure 1: Pie Diagram showing the distribution of Gravida

Among high-risk factors, 51(78.5%) antenatal women had gestational hypertension and preeclampsia, 8 (12.3%) antenatal women had gestational diabetes, and 28 (43.1%) had anaemia. Among these risk factors, only hypertension was associated with poor fetal outcomes.

About 42(65%) antenatal women were found to have oligohydramnios, and this was associated with poor outcomes because most women who had reduced liquor also had gestational hypertension and preeclampsia.

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Among flow patterns in fetal vessels, 34 antenatal women had abnormal flow patterns in the umbilical artery. 23(35.4%) had reduced diastolic flow pattern, 6(9%) had absent diastolic flow pattern and 5(7.7%) had reversed diastolic flow patterns in umbilical artery. Abnormal flow pattern in the umbilical artery is significantly associated with poor perinatal outcome [Table 1 & 2].. Cut off using the ROC curve for poor fetal outcome was 1.2 for Umbilical Artery PI and 0.9 for Umbilical Artery RI [fig 3 &4].

In the middle cerebral artery, 31(48%) antenatal women had increased diastolic flow due to brain sparing effect. Abnormal flow pattern in a middle cerebral artery is significantly associated with poor perinatal outcome, and the cut-off using the ROC curve for poor fetal outcome was 1.1 for MCA PI. [Table 3, Fig 5 & 6]. The cerebro-placental ratio was abnormal in 33(50.8%) antenatal women [Table 4 & Fig 7].

Flow patterns in the aortic isthmus and ductus venosus showed flow reversal in 6(9%) and was significantly associated with poor perinatal outcomes [Table 5].

Thus, in total, among 65 antenatal women, 35 had abnormalities in Doppler values, of which 27 had poor perinatal outcomes. Among the 65 subjects, 24(36.9%) had mild placental insufficiency or stage 1 FGR, 4(6.2%) had severe placental insufficiency or stage 2 FGR, 1(1.5%) had low suspicion signs of fetal acidosis or stage 3 FGR and 6(9.2%) had high suspicion of fetal acidosis or stage 4 FGR. Of the 65 subjects, 33(51%) antenatal women had caesarean section while 32(49%) had normal delivery [Figure 2].

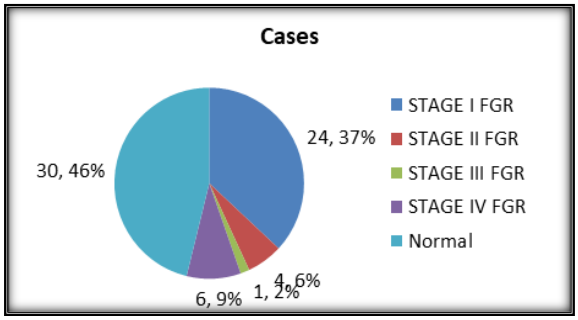

Figure 2: Pie Diagram showing the distribution of fetal growth restriction

Among perinatal mortality, 6 (9.2%) were intrauterine deaths, and 7(10.8%) were neonatal deaths. 13(22%) babies had APGAR score ≤ 6 at 5 minutes [Table 6].

Among neonatal complications, 8(12.3%) babies had respiratory distress syndrome, 11(16.9%) babies had sepsis, 7(10.8%) babies had hypoxic-ischemic encephalopathy, 4 (6.2%) had intracerebral or intraventricular haemorrhage. [Table 7]

About 11(18.6%) babies had NICU admission duration of 11 to 15 days, while 6(10.2%) babies had NICU admission duration of > 15 days. Among birth weight majority of the babies weighed around 1.6 to 2 kg, about 22(37.3%) babies, followed by a weight of around 2.1 to 2.5 kg, about 16(27.1%) babies.

Thus, in total, among 65 antenatal women, about 35 had abnormalities in Doppler values, of which 27 had poor perinatal outcomes.

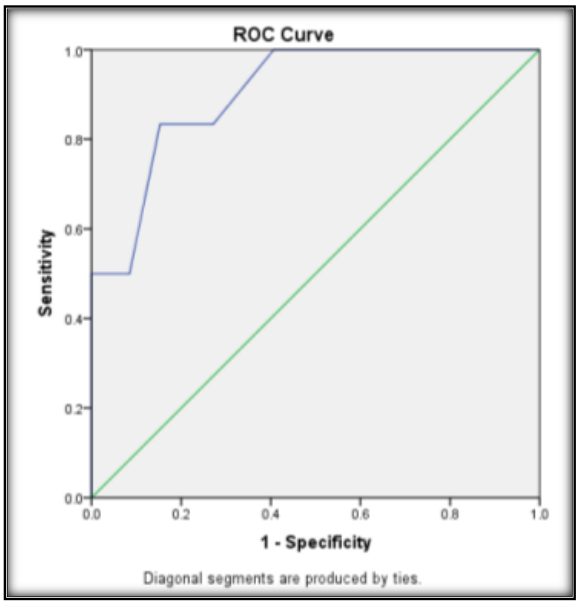

Figure 3: ROC curve showing umbilical artery pulsatility index vs perinatal outcome

Based on the values of the pulsatility index and resistive index collected from the umbilical artery and middle cerebral artery, a ROC curve was drawn, and cut-off values were obtained for differentiating the IUGR and non-IUGR group:

Cut-off value of umbilical artery PI at 1.2 with p-value of < 0.05 is significant. A cut-off value of umbilical artery RI at 0.9 with p-value of < 0.05 is significant. A cut-off value of the cerebroplacental ratio is 0.8 at p-value of <0.05 is significant.

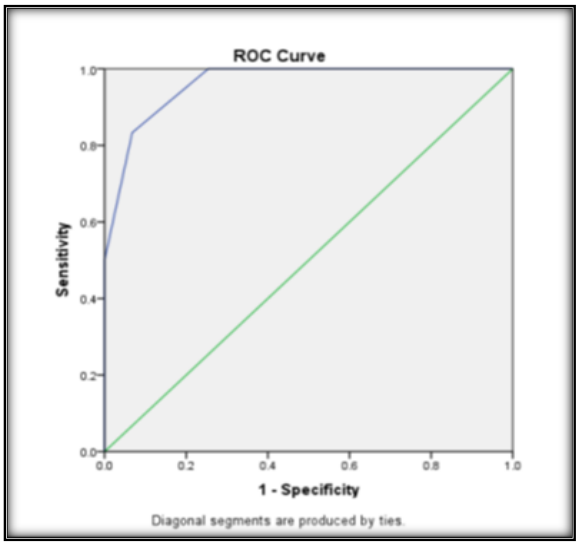

Figure 4: ROC curve showing umbilical artery resistance index vs perinatal outcome

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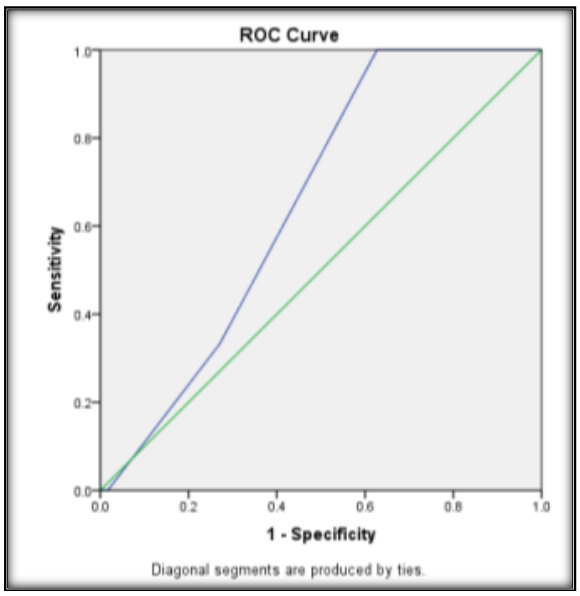

Figure 5: ROC curve showing middle cerebral artery resistance index vs perinatal outcome

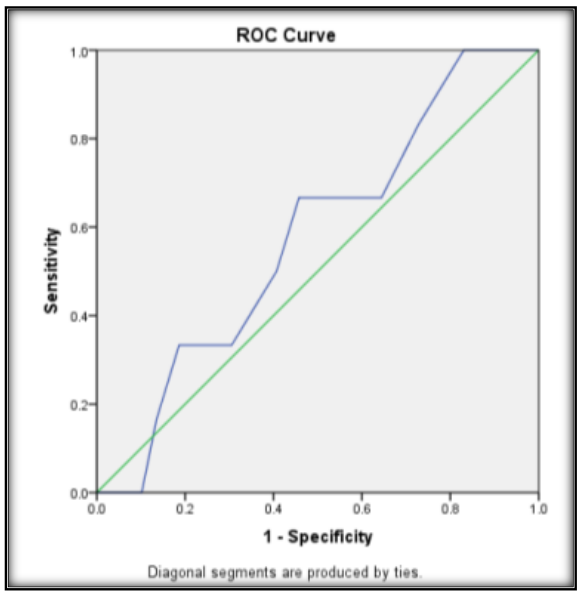

Figure 6: ROC curve showing middle cerebral artery pulsatility index vs perinatal outcome

Table 1: Distribution of Pattern of flow in Umbilical artery

Flow in diastole	Cases	
	No	%
Normal	31	47.7
Decreased diastolic flow	23	35.4
Absent diastolic flow	6	9
Reversed diastolic flow	5	7.7

Table 2: Comparison of Pattern of flow in Umbilical artery and Perinatal Outcome

Diastolic flow in the umbilical artery	Outcome		Total	P value
	Good	Poor		
Normal	27 (79.4)	4 (12.9)	31	0.01*
Decreased flow	7 (20.6)	16 (51.6)	23	
Absent flow	0	6 (19.4)	6	
Reversed flow	0	5 (16.1)	5	

Table 3: Comparison of Pattern of flow in Middle Cerebral Artery and Perinatal Outcome

Flow in diastole	Outcome		Total	P value
	Good	Poor		
Normal	26 (76.5)	8 (25.8)	34	0.01*
Increased Diastolic flow (Brain sparing effect)	8 (23.5)	23 (74.2)	31	

Table 4: Distribution of Cerebro-placental Ratio and flow in diastole

		Cases	
		No	%
CPR	>1.08	32	49.2
	<1.08	33	50.8

Table 5: Comparison of Pattern of flow in Aortic isthmus / Ductus venosus and Perinatal Outcome

Flow in diastole	Outcome		Total	P value
	Good	Poor		
Antegrade	34 (100)	25 (80.6)	59	0.01*
Retrograde	0	6 (19.4)	6	

Table 6: The distribution of APGAR score

APGAR score		Cases	
		No	%
At 1 minute	≤6	21	36
	>6	38	64
At 5 minutes	≤6	13	22
	>6	46	78

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Table 7: Frequency table showing the Distribution of Neonatal Complications

Neonatal complications	Cases	
	No	%
Nil	29	44.6
Respiratory distress syndrome	8	12.3
Sepsis	11	16.9
Hypoxic ischemic encephalopathy	7	10.8
Intracerebral/intraventricular haemorrhage	4	6.2
IUD	6	9.2

Table 8: ROC curve of various parameters vs perinatal outcome

	Sensitivity	Specificity	Area	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Umbilical artery pulsatility index	100	90	.904	.001	.796	1.000
Umbilical artery resistance index	90	70	.962	.001	.906	1.000
Middle cerebral artery resistance index	90	70	.652	.221	.485	0.82
Middle cerebral artery pulsatility index	70	70	.572	.533	.362	0.794
Cerebroplacental ratio	100	90	.772	.03	.636	0.907

Table 9: Cut off value

Cut Off Values	
UMBILICAL ARTERY PI	1.2
UMBILICAL ARTERY RI	0.9
MCA PI	1.1
CPR	0.8

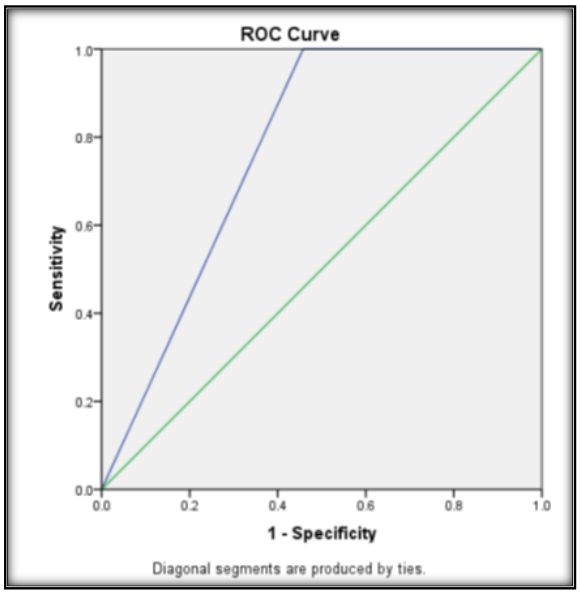

Figure 7: ROC curve showing cerebroplacental ratio vs perinatal outcome

DISCUSSION

Identifying fetal growth restriction in high-risk mothers helps provide adequate antenatal care, thus reducing perinatal mortality and morbidity. Changes in Doppler parameters follow a sequential pattern. Changes in umbilical and Middle cerebral arteries occur during the early stages of fetal hypoxia.[2] Changes follow this in the aortic isthmus and ductus venosus, indicating advanced fetal hypoxia and severe acidosis. The end spectrum is pulsatile flow seen in the umbilical vein, and decelerations follow this in Cardiotocography and fetal death if timely management is not done. The changes in Doppler parameters can be used for staging fetal growth restriction.[2-4]

According to Malik et al., 60 (60%) out of 100 cases had abnormal umbilical artery doppler, among which about 41(68%) had poor fetal outcomes.[3] In our study, 34 out of 65(52%) cases had abnormal umbilical artery Doppler, of which 27(79%) had poor fetal outcome.

In our study, 33 out of 65(50%) cases had abnormal cerebroplacental ratio, among which 27(81%) had poor fetal outcomes, and this was significantly associated with poor fetal outcomes (p-value 0.03). Umbilical artery PI (p-value 0.01) was significantly associated with poor fetal outcome. Our study found a similar association with a p-value of 0.001 for umbilical artery PI. Thus, the increasing severity of abnormal flow in the umbilical artery increases the risk of IUD and perinatal death.

According to Tantuway et al, 14 out of 43(32%) cases had retrograde flow in the aortic isthmus, of which all 14 had a poor perinatal outcome.[4] 7 out of 43(16%) cases had retrograde flow in ductus venosus, of which all 7 had poor perinatal outcomes. In our study, 6 out of 65(9%) had retrograde flow, and all had poor perinatal outcomes.

In our study, among perinatal mortality, 6 (9.2%) were intrauterine deaths, 7(10.8%) were neonatal deaths, and 13(22%) babies had APGAR score ≤ 6 at 5 minutes. According to a systemic evaluation by Imdad et al., the efficiency of umbilical artery Doppler velocimetry in "high-risk" pregnancies, together with the necessary intervention, decreased perinatal death by 29% (RR 0.71, 95% CI 0.52-0.98). However, the influence on stillbirth was reduced by 35% (RR 0.65, 95% CI 0.41-1.00), but the results did not meet the threshold for statistical significance.[7]

Doppler ultrasound of the umbilical artery in high-risk pregnancies dramatically decreased the number of prenatal hospitalisations (44%, 95% CI 28-57%), labour inductions (20%, 95% CI 10-28%), and

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Caesarean sections for foetal distress (52%, 95% CI 24-69%), according to Qahtani's review article. Additionally, the probability of perinatal fatalities was decreased by 38% (95% CI 15-55%) by the clinical action directed by Doppler ultrasonography. Post hoc studies showed that the Doppler group experienced a statistically significant decrease in elective deliveries, intrapartum foetal distress, and hypoxic encephalopathy.[8]

The changes in the ultrasound frequency of the Doppler signal, which targeted circulating foetal blood inside the umbilical artery, led to the use of Doppler ultrasound to analyse the pattern of waveforms in the umbilical artery throughout pregnancy. The foetal cardiac contraction force, blood density, artery wall elasticity, and peripheral or downstream resistance all affect the flow velocity waveforms (FVW) from the fetoplacental circulation. Observational studies have shown that the umbilical artery waveform displays forward blood flow throughout the cardiac cycle and is consistent with a low-resistance system when there is appropriate placental function. The umbilical arteries and veins were the subjects of the first studies. Still, more advanced technology has made it possible to examine the carotid and intracranial arteries, the aorta, the coronary circulation, the mesenteric artery, and the venous circulation (including the ductus venosus, inferior vena cava, and vena Galena).[9-11]

CONCLUSION

Any Doppler-triggered management protocol has the improvement of prenatal mortality and morbidity as its primary objective. An unnecessary early intervention could lead to excess preterm morbidity, whereas a wait could cause a stillbirth or a newborn with severe health problems.

Among the indices, increased umbilical artery pulsatility and resistive indices were significantly associated with poor perinatal outcomes. Hence, these values can be used to screen high-risk women and establish an institutional protocol for managing FGR in primary and secondary hospitals and to triage mpthers in need of referral to a tertiary care setting.

Based on the pulsatility index and resistive index collected from umbilical artery and middle cerebral artery in our study, a ROC curve was drawn, and cut-off values were obtained for the study population. The values include 1.2 for the umbilical artery pulsatility index, 0.9 for the umbilical artery resistive index and 1.1 for the middle cerebral artery pulsatility index. The cerebroplacental ratio cut-off was 0.8 as per ROC for poor fetal outcome.

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