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## Original Research Article

# The study of arterial and venous Doppler in high risk pregnancies and its role in perinatal outcome

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### ABSTRACT

**Background:** Antepartum foetal surveillance is the corner stone in the management of high risk pregnancies, aimed at reducing maternal and perinatal mortality and morbidity. This study was conducted to analyse the blood flow in umbilical artery, middle cerebral artery, umbilical vein and ductus venosus using doppler ultrasound in high risk pregnancies.

**Methods:** This was a prospective study conducted in pregnant patients with high risk factors after 28 weeks of gestation who got admitted in the Department of Obstetrics and Gynaecology at Care Hospital, Hyderabad during the period from October 2013 to December 2014.

**Results:** Patients were divided into two groups, first with normal Doppler and second with abnormal Doppler, containing 76 and 20 patients respectively. Group 2 is again 4 sub-groups according to the vessel affected. Group A included the cases with affected umbilical artery, Group B included the cases with affected middle cerebral artery, Group C included the cases with both affected umbilical artery and middle cerebral artery (UA+MCA), Group D included the Cases with the affected umbilical artery, middle cerebral artery and Ductus Venosus (UA+MCA+DV) containing 12, 2, 4 and 2 patients respectively. There were more number of emergency caesarean sections than vaginal deliveries which is statistically significant ( $p < 0.034$ ), there were more number of sick babies than healthy babies and there are more number of still births which is statistically significant ( $p < 0.0001$ ), there are more number of low birth weight babies in comparison to normal weight, which is statistically significant ( $p < 0.0037$ ). Distribution of cases with abnormal Doppler depending on vessel abnormality according to gestational age at the time of delivery, mode of delivery, perinatal outcome, birth weight, which was statistically significant. The sensitivity and specificity of abnormal Doppler in predicting perinatal outcome is 45% with (95% CI 26.9-64.0) and 89.5% with (95% CI 79.0-95.3) respectively. The positive predictive value is 65% with (95% CI 40.9-83.6) and negative predictive value is 78.9% with (95% CI 67.7-87.1).

**Conclusions:** This study recommends that all high risk pregnant women should undergo serial foetal monitoring. When doppler abnormalities are detected, delivery should be conducted at a tertiary care centre where facilities for caesarean section and NICU are present.

**Keywords:** Fetal distress, Hypertension in pregnancy, Stillbirths

### INTRODUCTION

Antepartum foetal surveillance is the corner stone in the management of high risk pregnancies, aimed at reducing maternal and perinatal mortality and morbidity.

Ultrasound has revolutionized the antepartum foetal assessment as a whole. Increased knowledge of the foetus in utero aids our efforts to detect the at-risk foetus. Intermittent auscultation of the foetus heart rate in labour began in the nineteenth century. Doppler assessment of

the placental circulation plays an important role in screening for impaired placentation and its complications. Assessment of the foetal circulation is essential in the better understanding of the pathophysiology of a wide range of pathological pregnancies and their clinical management.<sup>1</sup>

Doppler ultrasonography (DU) velocimetry of uteroplacental, umbilical, and foetal vessels (MCA, UV, DV) has become the established method for antenatal monitoring of foetal wellbeing. Circulatory changes, reflected in certain foetal Doppler waveforms, predict adverse perinatal outcome. Although umbilical arteries are the common vessels assessed by DU, studies have shown the efficacy of the middle cerebral artery (MCA) Doppler and Foetal Veins (Umbilical Vein and Ductus Venosus) also.<sup>2</sup>

Today, with the advancement of pulsed and colour coded DU combined with better reproducibility, the MCA has emerged as the vessel of choice in the Doppler assessment of foetal intracranial as well as another organs perfusion. Now-a-days the role of foetal venous Doppler velocimetry especially of the Ductus venosus is being evaluated in the prediction of foetal mortality in IUGR fetuses. Abnormal venous Doppler indices are highly suggestive of foetal acidaemia. Applicability of Doppler indices in the diagnosis of abnormalities is possible only when there are reference normal values for each index.<sup>3</sup>

This study was conducted to analyse the blood flow in umbilical artery, middle cerebral artery, umbilical vein and ductus venosus using doppler ultrasound in high risk pregnancies, to evaluate the role of Doppler ultrasound in the management of high risk pregnancies, to assess the value of Doppler ultrasound in analysing the perinatal outcome in high risk pregnancies.

## METHODS

This was a prospective study conducted in pregnant patients with high risk factors after 28 weeks of gestation who got admitted in the Department of Obstetrics and Gynaecology at Care Hospital, Hyderabad during the period from October 2013 to December 2014. 96 pregnant patients were selected for the study.

### *Inclusion criteria*

Antenatal cases beyond 28 weeks of gestation with the following high-risk factors, hypertensive disorders of pregnancies, foetal growth restriction, oligo-hydramnios, haematological disorders in pregnancy, diabetes with or without systemic changes, Rh-negative pregnancy, heart disease complicating pregnancy and bad obstetrics history, pre-term delivery, post datism and multiple gestation (i.e. twin pregnancy) and those who gave consent for the study.

### *Exclusion criteria*

Foetuses with congenital anomalies, intra-uterine death, wrong dates, not willing to participate and molar pregnancy, caesarean section for fetal distress, perinatal death, APGAR score at 5 min is <7, admission to NICU for reasons other than low birth weight alone like birth asphyxia, sepsis, respiratory distress syndrome, feeding intolerance, convulsions, hypoglycemia, hyperbilirubinemia, ventilator support, necrotizing enterocolitis.

All the patients selected for this study underwent history taking and examination at admission. The routine antenatal blood and urine investigations were done. The gestational age was based on last menstrual period (LMP), ultrasound biometry performed before the 20<sup>th</sup> gestational week, when the LMP is uncertain or not known and early ultrasound before 13 weeks has not been performed. Doppler velocity waveforms of uterine, umbilical and middle cerebral arteries were taken for high risk pregnancies with gestational age more than 28 weeks. Follow up Doppler studies were performed if clinically indicated to determine a favourable or a worsening trend in the Doppler indices. However, only the results of the first Doppler ultrasound were used for analysis of perinatal outcome. The patient was explained about the non-invasive/atraumatic nature of the procedure.

All the examinations were made with the patient lying in semi recumbent position with a lateral tilt. Synthetic ultra-gel was applied liberally over the abdomen to get a good acoustic coupling. The instrument used was Philips HD 11XE Colour Doppler ultrasound machine with a convex transducer of 2-5 MHz frequency. Doppler wave form was obtained after localizing the vessels by B mode real time scanner. Pulsed Doppler was used to get the Doppler signals after localizing the vessels. The maximum Doppler shift frequencies were obtained, and various ratios were calculated from each vessel. Doppler examination was done when foetus was in apnoeic state to avoid the influence of foetal respiration on Doppler signals.

Doppler waveforms of umbilical artery, middle cerebral artery, umbilical vein and ductus venosus are obtained as described. Steroids were administered as double dose 24 hours apart to all the women between 28 and 34 weeks to enhance foetal lung maturity. In patients with normal and abnormal Doppler, induction of labour was performed with prostaglandin E2 gel or oxytocin if spontaneous labour did not start in those women planned for vaginal delivery. If foetal distress developed in these women or those going into spontaneous labour developed foetal distress, emergency caesarean section was done. Elective caesarean section was done for associated obstetric indications.

Data collected included elective caesarean section rate, emergency caesarean section rate, normal or induced vaginal delivery rate, gestational age at delivery, birth weight, Apgar scores and admission to neonatal intensive care unit, perinatal mortality and subjected to statistics analysis with different parameters. Statistical analysis was done with SPSS-19 programme. Variables are described first, then compared with using ANOVA and Chi-square Test. P value <0.05 was considered significant.

## RESULTS

In the present study, 96 patients with various high-risk factors were subjected to foetal Doppler study and their perinatal outcome and other various parameters were studied. Based on the risk factors, the cases were distributed as follows; 26 cases had hypertensive disorders of pregnancy, 13 cases had foetal growth restriction, 32 cases had oligohydramnios, 6 cases had haematological disorders of pregnancy, 22 cases had diabetes, 7 cases had Rh-negative pregnancy, 5 cases had heart disease complicating pregnancy, 4 cases had BOH, 4 cases had preterm delivery, 5 cases had post datism and 6 cases had multiple gestation (twins). Many of the pregnant women have more than one risk factor. Hypertensive disorders of pregnancy and oligohydramnios constitute majority of cases followed by diabetes and FGR. Out of 96 high risk patients, based

on the doppler study, the cases were distributed as normal (76) which constituted 79.2%, abnormal (20) which constituted 20.8%

**Table 1: Demographics distribution in study.**

Age Groups	Normal Doppler		Abnormal Doppler	
	No.	%	No.	%
<20	9	11.8	2	10
21-25	30	39.5	9	45
26-30	30	39.5	7	35
31-35	6	7.9	2	10
>35	1	1.3	0	0
Total	76	100	20	100
<b>Gravidity</b>				
G1	38	50	12	60
G2	21	27.6	6	30
G3	12	15.8	2	10
G4	4	5.3	0	0
G5	1	1.3	0	0
Total	76	100	20	100

Out of 20 high risk cases with abnormal Doppler, 9 (45%) cases were from 21-25 yrs age group. 12 (60%) were primigravida. Out of 76 high risk cases with normal Doppler, 38 (50%) were primigravida followed by 21 (27.6%) were second gravida.

**Table 2: Distribution of cases according to Doppler study.**

Gestational age (weeks)	Normal Doppler		Abnormal Doppler	
	Number	Percentage	Number	Percentage
<28 (extreme preterm)	0	0	0	0
<32 (early preterm)	0	0	2	10
32-33.6 (moderate preterm)	2	2.7	0	0
34-36.6 (late preterm)	19	25	5	25
37-38.6 (early term)	27	35.5	10	50
39-40.6 (full term)	27	35.5	3	15
41-41.6 (late term)	1	1.3	0	0
42 (post term)	0	0	0	0
Total	76	100	20	100
<b>Mode of delivery</b>				
Vaginal	30	40	6	30
Elective LSCS	23	30	2	10
Emergency LSCS	23	30	12	60
Total	76	100	20	100
<b>Perinatal outcome</b>				
Healthy	60	79	7	35
NICU	16	21	11	55
Still birth	0	0	2	10
Total	76	100	20	100
<b>Birth weight</b>				
≥2.5 kg (normal)	57	75	8	40
<2.5-1.5 kg (slow)	17	22.4	8	40
<1.5-1.0 kg (very low)	2	2.6	3	15
<1.0 kg (extremely low)	0	0	1	10
Total	76	100	20	100

**Table 3: Distribution of cases with abnormal Doppler depending on vessel abnormality.**

Vessel	No. of cases	Percentage
Umbilical Artery (UA)	12	60
Middle Cerebral Artery (MCA)	2	10
UA + MCA	4	20
UA + MCA + DV	2	10
Total	20	100

While number of deliveries at late preterm were 5 in abnormal Doppler group in comparison to normal Doppler, which is statistically significant ( $p < 0.044$ ).

While out of 76 high risk cases with normal Doppler, 30 (40%) were delivered vaginally and 23 (30%) required emergency caesarean section, which is statistically significant ( $p < 0.034$ ). Normal Doppler, 60 (79%) were with healthy outcome, 16 (21%) were NICU admission and none were still birth. It was statistically significant ( $p < 0.0001$ ). None were extremely low birth weight.

Out of 20 high risk cases with abnormal Doppler, 12 (60%) cases with Umbilical artery abnormality, 2 (10%) cases with Middle Cerebral Artery abnormality, 4 (20%) cases with UA + MCA abnormalities, 2 (10%) cases with UA + MCA + DV abnormalities.

**Table 4: Distribution according to gestational age at the time of delivery in relation to vessel affected.**

Gestational age (weeks)	UA		MCA		UA + MCA		UA+MCA+DV	
	No.	%	No.	%	No.	%	No.	%
<28 (extreme preterm)	0	0	0	0	0	0	0	0
<32 (early preterm)	0	0	0	0	0	0	2	100
32-33.6 (moderate preterm)	0	0	0	0	0	0	0	0
34-36.6 (late preterm)	3	25	0	0	2	50	0	0
37-38.6 (early term)	6	50	2	100	2	50	0	0
39-40.6 (full term)	3	25	0	0	0	0	0	0
41-41.6 (late term)	0	0	0	0	0	0	0	0
42 (post term)	0	0	0	0	0	0	0	0
Total	12	100	2	100	4	100	2	100
<b>Mode of delivery</b>								
Vaginal	5	41.7	0	0	0	0	2	100
Elective LSCS	2	16.6	0	0	0	0	0	0
Emergency LSCS	5	41.7	2	100	4	100	0	0
Total	12	100	2	100	4	100	2	100
<b>Birth weight</b>								
>2.5 kg	7	58.3	2	100	0	0	0	0
<2.5 kg	5	41.7	0	0	4	100	2	100
Total	12	100	2	100	4	100	2	100
<b>Perinatal outcome</b>								
Healthy	6	50	1	50	1	25	0	0
NICU	6	50	1	50	3	75	0	0
Still birth	0	0	0	0	0	0	2	100
Total	12	100	2	100	4	100	2	100

Abnormal umbilical artery Doppler indices, 7 (58.3%) babies delivered were of normal weight ( $\geq 2.5$  kg) while 5 were low birth weight ( $< 2.5$  kg). MCA Doppler indices, 2 (100%) were born with normal weight ( $\geq 2.5$  kg). With abnormal UA+MCA Doppler indices, 4 (100%) were born with low birth weight. With abnormal UA+MCA+DV Doppler indices, 2 (100%) were born with low birth weight, which is significant ( $p < 0.041$ ). Abnormal UA+MCA+DV Doppler indices, 2 (100%) were still born which is significant ( $p < 0.0019$ ).

Sensitivity and specificity of abnormal Doppler in predicting perinatal outcome is 45% with (95% CI 26.9-64.0) and 89.5% with (95% CI 79.0-95.3) respectively.

**Table 5: Sensitivity and specificity of Doppler study.**

Doppler study	95% confidential limit	
True positive	9	-
False positive	11	-
True negative	60	-
False negative	16	-
Sensitivity	45%	26.9-64.0
Specificity	89.5%	79.0-95.3
Positive predictive value	65%	40.9-83.6
Negative predictive value	78.9%	67.7-87.1

The positive predictive value is 65% with (95% CI 40.9-83.6) and negative predictive value is 78.9% with (95% CI 67.7-87.1)

## DISCUSSION

During the period of study (October 2013 to December 2014), 102 patients were diagnosed with high risk factors, which can affect uteroplacental or fetoplacental circulation resulting in increased maternal and perinatal morbidity or mortality.

### *Distribution of cases according to gestational age at the time of delivery according to Doppler study*

In the present study high risk pregnancy with abnormal Doppler in comparison to high risk pregnancy with normal Doppler there are more number of deliveries at early term and also of preterm delivery, which is significant ( $p < 0.044$ ). Rochelson BL et al Fifty-four women who were delivered of small for gestational age infants were studied antenatally by serially continuous-wave Doppler velocimetry.<sup>5</sup>

Seventy-eight percent had an abnormal systolic/diastolic ratio. The group with an elevated systolic/diastolic ratio had a significantly higher incidence of abnormal foetal heart rate, pregnancy-induced hypertension, oligohydramnios, caesarean section for foetal distress, and admission into the neonatal intensive care unit. Average birth weight and gestational age at delivery were significantly lower in the group with an elevated systolic/diastolic ratio.

Figueras F et al have found that of the 369 SGA fetuses that had identified antenatally, 70 (19%) had an abnormal umbilical artery Doppler and the babies for these pregnancies had a higher risk for neonatal morbidity when compared with babies with normal birth weight (OR 3.99, 95% CI 1.04-11.03).<sup>6</sup> However the remaining 299 (81%) fetuses with normal umbilical artery Doppler had an elevated risk of neonatal morbidity (OR 2.66, 95% CI 1.04-4.39). Overall many of the instances of adverse outcome associated with small for gestational age were attributable to the group with normal Doppler than to the group with abnormal Doppler.

### *Mode of delivery according to doppler study*

In our study high risk pregnancy with abnormal Doppler in comparison to high risk pregnancy with normal Doppler there are more number of emergency caesarean sections than vaginal deliveries which is statistically significant ( $p < 0.034$ ). Hemalata D et al in their study have found that out of 49 cases with abnormal Doppler, 30 cases had caesarean section and 19 cases had vaginal deliveries, while out of 93 cases with normal Doppler 46 cases had caesarean section and 47 had normal vaginal delivery.<sup>7</sup>

### *Perinatal outcome according to Doppler study*

In Group 1 about 16 (21%) were shifted to NICU admission (sick babies) and none of the cases had still birth. While in Group 2 with abnormal Doppler, 7 (35%) babies were healthy, 11 (55%) babies were shifted to NICU, 2 (10%) were still birth.

In high risk pregnancy with abnormal Doppler in comparison to normal Doppler there are more number of sick babies than healthy babies and there are more number of still births which is statistically significant ( $p < 0.0001$ ). Hemlata D et al in their study, out of 49 cases of abnormal Doppler, 38 cases had NICU admission, while out of 93 cases with normal Doppler, 26 had NICU admission.<sup>7</sup>

Merchant RH et al have found, of the 75 fetuses studied, 33(44%) abnormal flow velocity waveforms (FVW) and only 30.3% of these had an uncomplicated outcome as compared to 81% of those with normal value. The mortality in cases with abnormal flows was 43% as compared to 7% in those with normal flow.

Rochelson BL et al fifty-four women who were delivered of small for gestational age infants were studied antenatally by serially continuous-wave Doppler velocimetry.<sup>5</sup> Seventy-eight percent had an abnormal systolic/diastolic ratio. The group with an elevated systolic/diastolic ratio had a significantly higher incidence of caesarean section for foetal distress.

### *Birth weight according to Doppler study*

In high risk pregnancy with abnormal Doppler in comparison to high risk group with normal Doppler, there are more number of low birth weight babies in comparison to normal weight, which is statistically significant ( $p < 0.0037$ ). Rochelson BL et al fifty-four women who were delivered of small for gestational age infants were studied antenatally by serially continuous-wave Doppler velocimetry.<sup>5</sup> Average birth weight was significantly lower.

### *Distribution of cases with abnormal doppler depending on vessel abnormality*

Group 2 with high risk pregnancy with abnormal Doppler, again divided into 4 sub-groups according to the vessel affected. Group A included the cases with affected Umbilical Artery, Group B included the cases with affected middle cerebral artery, Group C included the cases with both affected umbilical artery and Middle Cerebral artery (UA+MCA), Group D included the cases with the affected Umbilical artery, Middle Cerebral artery and Ductus Venosus (UA+MCA+DV) containing 12 (60%), 2 (10%), 4 (20%) and 2 (10%) patients respectively.



### ***Distribution of cases according to gestational age at the time of delivery in relation to vessel affected***

In Group A, (affected umbilical artery), 3 (25%) cases were delivered at full term (39-40.6 weeks), 6 (50%) delivered at early term (37-38.6 weeks), 3 (25%) delivered at late preterm (34-36.6 weeks). In Group B, (affected middle cerebral artery), 2 (100%) cases delivered at early term (37-38.6 weeks). In Group C, (affected umbilical artery and middle cerebral artery), 2 (50%) delivered at early term (37-38.6 weeks), 2 (50%) delivered at late preterm (34-36.6 weeks). In Group D, (affected umbilical artery, middle cerebral artery and ductus venosus), 2 (100%) cases were delivered at early preterm (<32 weeks).

### ***Mode of delivery in cases with abnormal Doppler according to vessel affected***

In Group A (affected umbilical artery), 5 (41.7%) cases were delivered vaginally, 2 (16.6%) cases were delivered by elective caesarean section, and 5 (41.7%) cases were delivered by emergency caesarean section. In Group B (affected middle cerebral artery) 2 (100%) cases were delivered by emergency caesarean section. In Group C (affected umbilical artery and middle cerebral artery), 4 cases were delivered by emergency caesarean section. In Group D (affected umbilical artery, middle cerebral artery and ductus venosus), 2 (100%) cases were delivered vaginally.

### ***Distribution of cases with abnormal Doppler according to birth weight in relation to vessel affected***

In Group A (affected umbilical artery), 7 (58.3%) babies born were having normal weight ( $\geq 2.5$  kg), 5 (41.7%) babies born were low birth weight (<2.5 kg). In Group B (affected middle cerebral artery), 2 (100%) babies born were having normal weight. In Group C (affected umbilical artery and middle cerebral artery), 4 (100%) babies born were having low birth weight. In Group D (affected umbilical artery, middle cerebral artery and ductus venosus), 2 (100%) babies born were having low birth weight, which is statistically significant ( $p < 0.041$ ).

### ***Perinatal outcome of cases with abnormal Doppler in relation to vessel affected***

In Group A (affected umbilical artery), 6 (50%) babies born were admitted to NICU while 6 (50%) were healthy and none had still birth. In Group B (affected middle cerebral artery), 1 (50%) baby was admitted to NICU and 1 (50%) baby born was healthy and none were still born. In Group C (affected umbilical artery and middle cerebral artery), 1 (25%) baby born was healthy while 3 (75%) babies had NICU admission. In Group D (affected umbilical artery, middle cerebral artery and ductus venosus), 2 (100%) were still born which is statistically significant ( $p < 0.0019$ ). Hence study of venous Doppler in high risk pregnancies plays an

important role in predicting perinatal mortality. Bras and Platt et al confirmed the association of absent end diastolic flow with adverse foetal outcome.<sup>9</sup> Out of 550 high-risk patients studied with umbilical velocimetry over this period, 12 patients showed the finding. All patients were delivered of small for gestational age fetuses and the perinatal mortality in this group was 50%. There was also significant perinatal morbidity as judged by caesarean section performed because of foetal distress, low Apgar scores, days in neonatal intensive care, prematurity, placental infarcts, and lethal anomalies. These findings suggest that reverse end-diastolic velocity on umbilical velocimetry is associated with catastrophic perinatal outcome, and aggressive perinatal management may be advised in this group of patients.

### ***Sensitivity and specificity***

The sensitivity and specificity of abnormal Doppler in predicting perinatal outcome is 45% with (95% CI 26.9 - 64.0) and 89.5% with (95% CI 79.0-95.3) respectively. The positive predictive value is 65% with (95% CI 40.9-83.6) and negative predictive value is 78.9% with (95% CI 67.7 - 87.1). Hemalata D et al in their study the positive predictive value of Doppler P.I for detecting abnormal foetal outcome was 94%, the sensitivity was 71% specificity was 94% and negative predictive value was 65%.<sup>7</sup> Trudinger BJ reported sensitivity and specificity of middle cerebral artery of 35 and 56 respectively with positive predictive value of 35 and negative predictive value of 56, in their study of flow velocity waveforms in the maternal uteroplacental and foetal umbilical placental circulations.<sup>10</sup> Alfievic Z et al conducted a study in which eighteen completed studies involving just over 10,000 women were included.<sup>11</sup> The trials were generally of unclear quality with some evidence of possible publication bias. The use of Doppler ultrasound in high-risk pregnancy was associated with a reduction in perinatal deaths (risk ratio (RR) 0.71, 95% confidence interval (CI) 0.52 to 0.98, 16 studies, 10,225 babies, 1.2% versus 1.7%, number needed to treat (NNT) = 203; 95% CI 103 to 4352). There were also fewer inductions of labour (average RR 0.89, 95% CI 0.80 to 0.99, 10 studies, 5633 women, and random-effects) and fewer caesarean sections (RR 0.90, 95% CI 0.84 to 0.97, 14 studies, 7918 women). No difference was found in operative vaginal births (RR 0.95, 95% CI 0.80 to 1.14, four studies, 2813 women), nor in Apgar scores less than seven at five minutes (RR 0.92, 95% CI 0.69 to 1.24, seven studies, 6321 babies). Current evidence suggests that the use of Doppler ultrasound in high-risk pregnancies reduced the risk of perinatal deaths and resulted in less obstetric interventions.

### ***CONCLUSION***

Foetal Doppler studies are an important method of foetal surveillance especially in high risk pregnancy. Foetus in high risk pregnancy is at risk of hypoxia and FGR. The

present study indicates the value of abnormal Doppler in the diagnosis of low birth weight babies who may require early delivery and high-risk pregnancies which may be associated with poor perinatal outcome. With abnormal Doppler, mother is also at risk of increased morbidity due emergency caesarean section. Hence it is recommended that all high risk pregnant women should undergo serial foetal monitoring. When Doppler abnormalities are detected, delivery should be conducted at a tertiary care centre where facilities for caesarean section and NICU are present.

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