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Role of Doppler Ultrasound in High Risk Pregnancies in Predicting Feto-Maternal Outcome

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Abstract

Aim: To study the role of color Doppler ultrasonography in high risk pregnancy in predicting maternal outcome depending on gestational age at the time of delivery and mode of delivery. *Material and Methods:* 50 women with high risk pregnancies were diagnosed and recruited for the study. Doppler indices carried out to predict perinatal outcome like birth weight and comparison of the accuracy of various Doppler parameters were also done for maternal and perinatal outcome. APGAR score at 5 minutes calculated. Perinatal morbidity and mortality were recorded. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy weredetermined for all Doppler measurements were also done. *Results:* In the present study group, 28(56%) of women were in the age group of 21 – 25 years. 20(40%) of women had PIH and 32(64%) had abnormal Doppler. In 32 women with abnormal Doppler, 28 (87.5%) had caesarean section and 4 (12.5%) had vaginal delivery. In abnormal doppler group out of 28 caesarean sections, 18 (64.2%) women had caesarean section for fetal distress. The mean birth weight of the babies born to women in the study group was 2.3kg. Out of 32 newborns in abnormal doppler group 12 (37.5%) newborns had APGAR <7 and 20 (62.5%) newborns had APGAR ≥7. Umbilical artery Doppler was found to have sensitivity 46.6%, specificity – 94%, PPV - 93%, NPV - 54%. Middle cerebral artery Doppler was found to have sensitivity 73.3%, specificity – 90%, PPV – 91.6%, NPV- 69.3%. CPR abnormality was found to have sensitivity 86.6%, specificity – 95%, PPV – 96.2%, NPV – 82.6%. *Conclusion:* The results of the present study supports the use of doppler study of both umbilical, middle cerebral arteries wave forms as a primary tool for antenatal surveillance in high risk pregnancies.

Keywords: APGAR Score; Maternal Outcome; Doppler Ultrasonography; High Risk Pregnancies.

Introduction

Pregnancy is a unique, physiologically normal event in a women's life. However, a pre-existing disease or an unexpected illness of the mother or fetus can complicate the pregnancy. High risk pregnancies are a small segment of obstetric population that produces the majority of the maternal and fetal mortality and morbidity. In India, 20-30% pregnancies belong to high risk category accounting for 80% of maternal and 75% of perinatal deaths [1].

Eventhough there is a decreasing trend in the maternal and infant mortality rates in the past two decades due to the advances in Obstetric and Neonatal care, there is still an increasing need for early detection of high risk pregnancies and their intensive care. The detection of morbid changes in the fetal status followed by timely intervention to avoid death or disability is one of the most important objectives of prenatal care.

The development of a good utero-placental circulation is essential for achievement of a normal

outcome of fetus and mother. The largest advances have been made in the assessment of the fetus at risk of hypoxia and death secondary to placental insufficiency. There are numerous tests available for this purpose. Doppler investigation of middle cerebral artery in combination with umbilical artery seems to improve prediction of adverse outcome in near-term pregnancies [26]. With advent of doppler ultrasound it is possible to determine the placental vascular insufficiency early and identify the fetal hemodynamic adaptation to decreased placental blood flow,and fetal hemodynamic decompensation that resulting in hypoxaemia and acidosis with the help of Doppler. On the basis of abnormal Doppler results, obstetrical decision making [27] might improve and prevent intrauterine death because hypoxic cerebral damage may begin before labor [28] and intrapartum asphyxia is probably more damaging when superimposed on underlying hypoxia.

The role of umbilical artery and middle cerebral artery in the evaluation of fetuses at high risk for poor outcome has been adequately assessed in randomized cilinical trials [1]. This method has been found to be useful to complement other methods of fetal surveillance such as the NST or the BPP, to determine more precisely the degree of fetal compromise. It is a follow up test when other tests of fetal well being give ambiguous results and to determine more accurately the time of delivery. It helps to evalaute the presence of fetal anaemia and its severity.

So this diagnostic modality has gained prime importance in the area of high risk pregnancy evaluation. The hypothesis that Doppler is effective in reducing mortality and major morbidity in high-risk pregnancy could only be tested with a massive randomized trial [29]. The present study is designed to evaluate the role of Doppler Velocimetry of uteroplacental and fetoplacental circulation in the prediction of maternal and perinatal outcome in high risk pregnancies.

Methodology

Source of Study

This is a prospective study conducted in the department of Obstetrics and Gynaecology, Naryana Medical College & Hospital, Nellore for a period of 2 years.

50 women with high risk pregnancies were diagnosed and recruited for the study after informed consent.

Inclusion Criteria

All women with high risk pregnancies with gestational age ≥32 weeks, with singleton pregnancy and with following conditions included in the study

- PIH
- IUGR
- Gestational diabetes
- Renal disease

Exclusion Criteria

Women with the following conditions were excluded

- Multiple gestations
- Cardiovascular disease
- Essential hypertension.
- Fetus with congenital anomalies

Patient Analysis

- Detailed history including age, obstetric history and menstrual history were taken.
- Gestational age was calculated from the early scan taken before 13 weeks of gestation and from LMP,If menstrual cycles are regular.
- Detailed general examination, abdominal examination and local examination were done.
- Informed consent was taken and data recorded on the proforma.
- Patients were subjected to routine and specific investigations pertaining to associated condition.
- Patients were subjected to serial color doppler ultrasonography from 32 weeks of gestation.

Procedure

The patient was explained about the non-invasive/ atraumatic nature of the procedure.The instrument used was Philips HD 11XE Color Doppler ultrasound machinewith a convex transducer of 2-5 MHz frequency. Doppler wave form was obtained afterlocalizing the vessels by B mode real time scanner. Pulsed Doppler was used to get theDoppler signals after localizing the vessels. Doppler examinationwas done when fetus was in apneicstate to avoid the influence of fetal respiration onDoppler signals. The signal was recorded for a minimum of 5-8 cycles with blood flow velocity waveforms of equal shape and amplitude and satisfactory quality. Then the image was frozen and measurements were taken.

Identification of Various Arteries and Their Criteria

1. *Umbilical Artery:* Doppler signals were acquired frommid portion of cord. Values of S/D ratio, RI and PI>95th percentile as per the Harrington et al Doppler indices, absent enddiastolic velocity (AEDV) and reversed end diastolic velocity (REDV) were consideredabnormal.
2. *Middle Cerebral Artery (MCA):* MCA was visualized in transverse axial view offetal head at a slightly more caudal plane than the one used for BPD. PI and RI < 5TH percentile as per the Harrington et al Doppler indices were considered abnormal.
3. *Cerebro Placental Ratio:* It is the ratio of Middle cerebral artery PI and Umbilical artery PI. Value less than 5th percentile was considered abnormal. If Doppler is normal it was repeated after 2 weeks. In case of abnormal Doppler, it was repeated according to the associated risk. The last Doppler resultbefore delivery was considered for subsequent correlation of maternal and fetal outcome .

Maternal Outcome: Gestational age at time of delivery.

Mode of delivery.

Fetal Outcome: Birth weight.

APGAR score at 5 min.

Perinatal morbidity and mortality.

Statistical Analysis

Statistical analysis was done by using proportions. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy weredetermined for all Doppler measurements using the following formulae.

$$\text{SENSITIVITY} = \frac{A}{A+C} \times 100$$

$$\text{SPECIFICITY} = \frac{B}{B+D} \times 100$$

$$\text{POSITIVE PREDICTIVE VALUE} = \frac{A}{A+B} \times 100$$

$$\text{NEGATIVE PREDICTIVE VALUE} = \frac{D}{C+D} \times 100$$

A = True positive

B = False positive

C = False negative

D = True negative.

Results

In the present study group, 28 (56%) of women were in the age group of 21 – 25 years (Table 1).

In Gravidity, 32 (64%)cases belongs to primigravidae and 18 (36%) cases belongs to Multigravidae. 29 (58%) cases recorded in 32-36 weeks of gestation and 21(42%) cases recorded in 37-40 weeks of gestational ages.

20 (40%) of women had PIH, 12(36%) had IUGR, 10 (20%) had PIH along with IUGR and 2 (4%) had GDM. In 50 women with high risk pregnancy, 32 (64%) had abnormal Doppler and 18 (36%) of women had normal doppler. Umbilical artery doppler abnormality was seen in 15 (30%) of patients. Middle cerebral artery Doppler abnormality was noted in 24 (48%) and CPR abnormality in 27 (54%) of women in the study group. Out of 50 women with high risk pregnancy, 10% had AEDF and 2% had REDF.

Table 1: High risk pregnancy - Age distribution

Age in years	n/t	%
<20	6/50	12
21-25	28/50	56
26-30	14/50	28
>30	2/50	4

Mean gestational age at the time of delivery was 35 weeks in the present study group.

18 women with normal Doppler group, 6 (33.3%) had caesarean section and 12 (66.6%) had vaginal delivery. In normal doppler group out of 6 caesarean sections, 1 women had caesarean section for fetal distress, 3 for severe PIH and 2 for failed induction.

In 32 women with abnormal Doppler, 28 (87.5%) had caesarean section and 4 (12.5%) had vaginal delivery (Table 2).

In abnormal doppler group out of 28 caesarean sections, 18 (64.2%) women had caesarean section for fetal distress, 3 (10.7%) for severe PIH and 7 (25%) for failed induction (Table 3) (Figure 1).

The mean birth weight of the babies born to women in the study group was 2.3kg. In normal doppler

group, 22.3% of babies have birth weight less than 2.5 kg and 77.7% of babies have birth weight more than 2.5 kg. In abnormal doppler group, 87.5% of babies have birth weight less than 2.5 kg and only 12.5% of babies have birth weight more than 2.5 kg (Table 4).

Out of 18 newborns in normal doppler group, 1 (5.5%) newborn had APGAR <7 and 17 (94.5%) newborn had APGAR ≥ 7. Out of 32 newborns in abnormal doppler group 12 (37.5%) newborns had APGAR <7 and 20 (62.5%) newborns had APGAR ≥ 7 (Table 5).

18 babies in normal doppler group, 2 (11.1%) babies required NICU admissions and 16 (88.9%) babies were not admitted in NICU. Out of 2 admissions in NICU, 1 baby had low birth weight and 1 baby had Neonatal respiratoty distres. 32 babies in abnormal doppler group, 28 (87.5%) babies were admitted in NICU and

Table 2: Doppler - Mode of delivery

	Normal doppler		Abnormal doppler		Total	
	n/t	%	n/t	%	n/t	%
Vaginal	12/18	66.6	4/32	12.5	16/50	32%
LSCS	6/8	33.3	28/32	87.5	34/50	68%

Table 3: Doppler - Indication for Caesarean section

Indication for CS	Abnormal doppler		Normal doppler		Total	
	n/t	%	n/t	%	n/t	%
Fetal distress	18/28	64.2	1/6	16.6	19/34	55.8
Severe PIH	3/28	10.7	3/6	50	6/34	17.6
Failed induction	7/28	25	2/6	33.4	9/34	26.6

Table 4: Doppler - Birth weight

Birth weight	Normal		Abnormal		Total	
	n/t	%	n/t	%	n/t	%
< 2.5 kg	4/18	22.3	28/32	87.5	32/50	64
≥ 2.5 kg	14/18	77.7	4/32	12.5	18/50	36

Table 5: Doppler - APGAR SCORE (5')

APGAR	Normal		Abnormal		Total	
	n/t	%	n/t	%	n/t	%
< 7	1/18	5.5	12/32	37.5	13/50	26
≥7	17/18	94.5	20/32	62.5	37/50	74

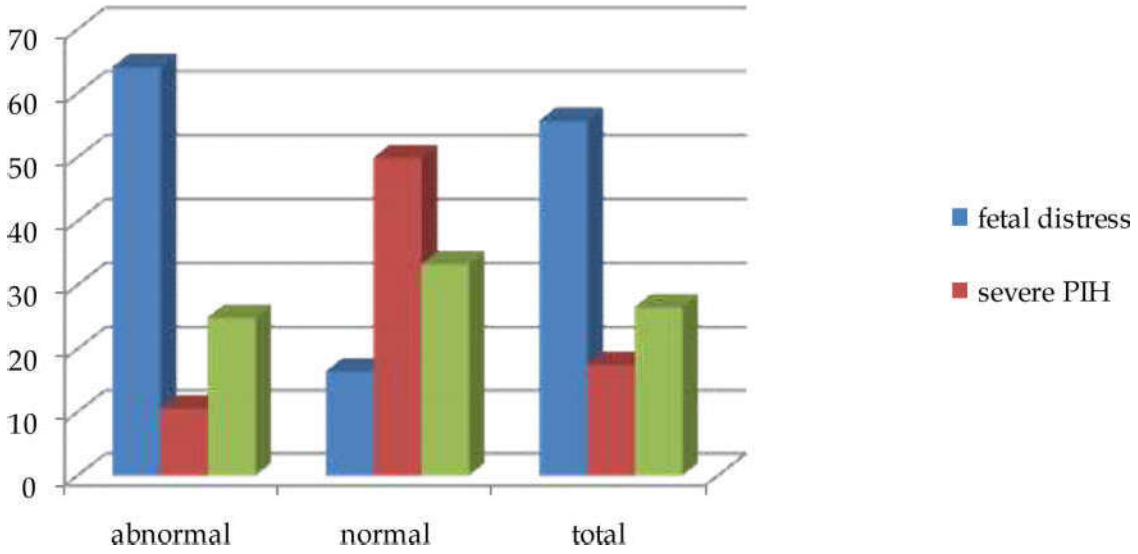

Fig. 1: Indication for Caesarean section

Table 6: Doppler – Indications for NICU admissions

Indication for NICU admission	Abnormal doppler n/t	%	Normal doppler n/t	%
Low birth weight	13/28	46.4	1/ 2	50
Neonatal respiratory distress	9/28	32.14	1/2	50
Intraventricular haemorrhage	3/28	10.7	-	
Necrotizing enterocollitis	3/28	10.7	-	

Table 7: Doppler indices – Sensitivity and Specificity

	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV
UA	14	19	1	16	46.6	94	93	54
MCA	22	18	2	8	73.3	90	91.6	69.3
CPR	26	19	1	4	86.6	95	96.2	82.6

4 (12.5%) were not admitted in NICU. Out of 28 admissions in NICU, 13 babies for low birth weight, 9 babies for Neonatal respiratory distress, 3 babies had Intraventricular haemorrhage and 3 had Necrotizing enterocolitis (Table 6).

There were no neonatal deaths in the normal Doppler group. Perinatal mortality in abnormal Doppler group was 25%. Perinatal mortality in babies with AEDF and REDF was 100%.

Among 15 women with umbilical Doppler abnormality, perinatal morbidity seen in 8 babies, there were 6 early neonatal deaths and 1 baby is healthy. Out of 24 women with middle cerebral artery Doppler abnormality, perinatal morbidity seen in 20 babies, 2 early neonatal deaths and 2 babies are haelthy. 27 women with CPR abnormality perinatal morbidity seen in 19 babies, there were 7 early neonatal deaths and 1 baby was healthy.

Umbilical artery Doppler was found to have sensitivity 46.6%, specificity – 94%, PPV - 93%, NPV - 54%. Middle cerebral artery Doppler was found to have sensitivity 73.3%, specificity – 90%, PPV – 91.6%, NPV- 69.3%. CPR abnormality was found to have sensitivity 86.6%, specificity – 95%, PPV – 96.2%, NPV – 82.6% (Table 7).

Discussion

High risk pregnancy women warrant a highly sensitive and specific diagnostic test which can be non invasively applied on a large scale. The traditional methods of fetal surveillance like NST, FHR monitoring and fetal biophysical profile are less reliable, because of their inability to detect early stage of fetal compromise with a significant number of false positive tests and low predictive value. Doppler is one such example of non invasive tests.

In high risk pregnancy women, placental insufficiency causes decrease in growth of the fetus as a primary adaptive response. If placental insufficiency persists, it causes metabolic deterioration and fetus loses ability to adapt hypoxaemia. These changes are reflected on arterial Doppler ultrasound by increased umbilical artery resistance without centralization of flow (MCA S/D ratio > UA S/D ratio), increased umbilical artery resistance with centralization of flow (MCA S/D ratio < UA S/D ratio), absent end diastolic flow and reversal of umbilical artery flow [2].

Increased end-diastolic pressure in the right ventriclecombined with decreased cardiac compliance, is reflected in a decrease, absence and ultimate reversal of blood flow in the ductus venosus during the atrial systolic component of the waveform later increased reversal of flow in the inferior vena cava is also noted. Using the combination of arterial and venous Doppler testing can result in identification of the majority of fetuses with acidemia (sensitivity 70-90% and specificity 70-80%) [3].

If doppler study is normal follow up is done bi-weekly. Experts have recommended Doppler surveillance up to 2-3 times per week when IUGR is complicated by oligohydramnios or abnormal umbilical artery indices [4].

In the present study group of 50 women with high risk pregnancy, 56% of women belong to the age group of 21 – 25 years, which is correlating to the studies done by Malikarjunappa et al [5] (56%) and Teena Nagar et al [6] (55%).

In the present study, a higher number of women were (56%) in the age group of 21-25 years and 64% were primigravidae and is close to the studies done by BN. Lakhkar et al [7] (60.3%) and GV.Prasad et al [8] (54%). The mean gestational age at the time of delivery was 35 weeks and is correlating to the studies

done by Rozeta et al [9] (34.8) and Deshmukh Anshul et al [10](34.4).

Majority of high risk pregnancies were terminated at or above 34 weeks either in the interest of mother or because of fetal compromise, expecting a good fetal survival rate at this gestation. So the mean gestaional age in the present study group and in all mentioned studies was around 34 – 35 weeks of gestation.

In the present study group, PIH was the most prevalent risk factor (40%) followed by IUGR (36%). PIH was the most prevalent risk factor in other studies like Komuhangi et al [11] (90%).

In the present study group of 50 women, 64% of women had doppler abnormality, which is correlating to the studies done by Manikyrao et al[12] (58%) and Dhand Hemlata [13] (61%).

The present study includes all high risk pregnancies like PIH, IUGR and Gestational diabetes mellitus and all are associated with placental insufficiency resulting in fetal hypoxia and acidosis. This explains the reason for high incidence of Doppler abnormality in the present study group.

In present study group, 40% of women had PIH. So umbilical artery abnormality was noted in 30% of high risk pregnancies. This correlates to studies done by Swati Goyal et al [14] (35%) and Shahino Bano et al [15] (26.6%).

In the present study, middle cerebral artery abnormality was noted in 48% of women which is close to studies done by Uma et al [16] (40%) and Abdelhassib Saleh et al [17] (44%).

The high incidence of middle cerebral artery abnormality is due to high number of PIH and IUGR cases, where abnormal middle cerebral artery doppler is common in both the conditions as a adaptation of fetus to decreased feto placental circulation.

In present study, cerebroplacental ratio abnormality was noted in 54% of women which is correlates with Abdelhassib Salah et al [17] (55%)

Cerebroplacental ratio is measured as middle cerebral artery PI to umbilical artery PI ratio. So it becomes abnormal when either middle cerebral artery PI decreases (seen in IUGR cases), umbilical artery PI increases (seen in PIH cases) or both.

In the present study group of 50 women, 68% of women had caesarean section and it is correlating with studies done by Young JI Byun et al [18] (69.7%) and Abhilasha Bansal et al [19] (70%).

Most of the patients with abnormal Doppler after 32 weeks were either delivered by caesarean section or induced for vaginal delivery. Most of the women who had induction of labour were taken up for emergeny caesarean section because of fetal distress and few cases in view of failed progression.

In the present study group, 67% of women had emergency caesarean section and this correlates to studies done by Mohammed Ismail Syed et al [20] (63%) and Teena Nagar et al [6] (71.5%).

In the present study, 55.8% of women had emergency caesarean section for fetal distress. This is close to the studies done by Arathi AP et al [21] (54.5%) and Mohd Khalid et al [20] (50%). In present study, mean birth weight was 2.3 kg and this correlates to the studies done by Sharma Urmila et al [23] (2.3 kg) and Abhilasha Banshal et al [17] (2.3kg).

Doppler abnormalities were associated with low birth weight because of early termination of pregnancies in view of fetal interest and for severe PIH. Higher number of IUGR pregnancies in the study group also explains the reason for mean birth weight being 2.3 kg.

In the present study group of 50 women, 74% of babies have APGAR ≥ 7 at 5 minutes. This correlates to studies done by Sharma Urmila et al [23] (74%) and Shahino Bano et al [15](74%). 60% of newborns were admitted in NICU, this is close to studies done by S. Manikya Rao et al [12] (63%) and BN. Lakhkar et al [7] (66%).

The high number of NICU admissions were due to preterm, low birth weight, respiratory distress in present study. Babies born with abnormal umbilical artery flow had intraventricular haemorrhage and necrotising enterocolitis.

In 18 women with normal doppler study, only 2 babies were admitted in NICU, 1 for low birth weight and other baby for respiratory distress due to meconium aspiration.

In present study, perinatal mortality was 16%. This correlates to the studies done by RK.Morris et al [24] (14.4%) and Mikovic et al [25] (14.3%).

Increased impedance in diastolic flow and ultimate reversal have correlation with severity of fetoplacental insufficiency and resulted in adverse perinatal outcome. Most of the perinatal deaths were noted with severe umbilical artery abnormality in the form of absent end diastolic flow and reversal of end diastolic flow. There were no perinatal deaths noted in the babies with normal doppler.

In present study, AEDF in umbilical artery was seen in 10% of women which is correlating to the studies done by GV. Prasad et al [8](6%) and S. Manikyrao et al [12] (10%).

In the present study, REDF in umbilical artey is seen in 2% of women. This is correlating to the studies done by Narula Harneet et al [26] (2%) and Dhand Hemlata et al [13] (1.4%). The incidence of REDF is less because most of the pregnancies were terminated at or before development of AEDF in umbilical artery. There was only one case with REDF in umbilical artery doppler.

In present study, perinatal mortality in women with AEDF and REDF is 100%, which is correlating to the studies done by GV. Prasad et al [8] (100% PNMR) and Mohd Khalid et al [22] (100%). This high perinatal mortality rate in these babies may be due to severe fetal hypoxia and metabolic acidosis by the time of AEDF and REDF.

Umbilical artey is the signature vessel in doppler study of the fetus as it is a direct reflection of the flow within the placenta. In the present study group umbilical artery doppler has specificity is 94% and PPV is 93% in predicting adverse perinatal outcome. This correlates to the study done by Khanduri Sachin et al [27] (specificity – 94.4%, PPV -96.3%) and Malik Rajesh et al [28] (specificity – 80%, PPV – 96.6%).

Umbilical artery doppler alone is less senstive in predicting adverse perinatal outcome. So it is important to monitor the other vessels also in predicting accurately the fetal well being.

MCA is the vessel of choice to assess the fetal compromise to decreased fetoplacental outcome because it is easy to identify and has a high reproducibility. In the present study, middle cerebral artery doppler has specificity of 90% and PPV of 91.6% in predicting adverse perinatal outcome. This is close to the studies done by Dhand Hemlata et al [13] (specificity- 92%, PPV – 94%) and Alaa Ebrashy et al [29] (specifictiy – 72.7%, PPV – 94%).

In normal pregnancies, the diastolic component in cerebral arteries is lower than in the umbilical artery at any gestational age. Therefore the cerebrovascular resistance remains higher than the placental resistance and MCA PI / UA PI is greater than 1. Index becomes less than 1, if flow distribution is in favor of the brain in fetal compromise.

In present study, cerebroplacental ratio has senstivity of 86.6%, specifictiy of 95% and PPV of 96.2% in predicting adverse perinatal outcome. This coorelates to the studies done by Shahino Bano et al [15] (senstivity – 83.3%, specificity – 100, PPV -100%).

In the present study, cerebroplacental ratio is more sensitive (86.6%) and specific (95%) in predicting adverse perinatal outcome. Its positive predictive value is 96.2%. This is comparable to the studies done by Malik Rajesh et al[28] (CPR, senstivtiy - 68%, specificity – 100%, PPV -100, NPV – 26.3) and GV. Prasad et al [8] (CPR, senstivity – 90, specificity -88, PPV – 87, NPV – 33.3. It is better predictor of adverse perinatal outcome than umbilical artery or middle cerebral artery alone.

Conclusion

Doppler should serve to minimise interventions and iatrogenic complications in high risk patients. Hence the importance of timely doppler studies and waveform analysis in high risk pregnancies should be over emphasized. The results of the present study supports the use of doppler study of both umbilical, middle cerebral arteries wave forms as a primary tool for antenatal surveillance in high risk pregnancies. Further research aimed at delineating strategies for the diagnosis and management of the growth restricted foetus is needed to guide the intelligenceof Doppler velocimetry into clinical perinatal practice.

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