Doppler Indices in Prediction of Fetal Outcome in Hypertensive Pregnant Women

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Abstract

Aim: To determine the role of Color Doppler Sonography in evaluation of fetal outcome in normal and hypertensive pregnant females.

Method: The study was carried out on 58 antenatal females (22 normotensive, 36 hypertensive) in their third trimester of pregnancy. After detailed history taking and physical examination, study of various arteries was performed using color Doppler ultrasound {TOSHIBA ECCO-CE CX} with 3.5 MHz curvilinear probe. Doppler measurements were taken with the mother in recumbent position during fetal inactivity and apnea. Arteries evaluated included – bilateral uterine arteries, umbilical artery, fetal middle cerebral and fetal aorta. Calculation of Systolic/Diastolic ratio(S/D), resistive (RI) and pulsality indices (PI) was done .The indices were correlated with fetal outcome.

Results: In our study, 34(94.44%) out of 36 hypertensive patients showed abnormal uterine artery flow of which 11 {32.35%} had intrauterine growth retardation (IUGR) and 1 Intrauterine death of fetus (IUD) as fetal outcome. 29 patients of 36 hypertensive patients had abnormal umbilical artery flow of which 11{30.5%} had IUGR as fetal outcome. Only one patient having severe hypertension had reversed end diastolic velocity (REDV) in umbilical artery and had sudden IUD. Another patient had absent end diastolic velocity (AEDV) and the baby expired 2 days after birth. 28 (77.78%) patients showed brain sparing effect {BSE} with reduced value of indices in fetal middle cerebral artery. Out of these, 11(30.5%) patients had small for gestational age (SGA) babies and 1(2.7%) had IUD. In hypertensive pregnancies 22 (61.1%) cases showed values of S/D, RI and PI above 2 SD, of which 11(50%) patients had SGA babies.

Conclusion: Color Doppler can detect changes in fetomaternal and uteroplacental circulation accurately which seem to correlate strongly with the pregnancy outcome; abnormal indices showing strong correlation with adverse fetal outcome. It helps us to monitor fetal well being, take timely action, plan the treatment and prevent adverse fetal outcome in high risk pregnancies.

Keywords: Color Doppler, hypertensive, normotensive

Introduction

The main goal of prenatal testing is to identify fetuses at increased risk for perinatal morbidity and mortality. The traditional methods of fetal surveillance like non stress test, fetal heart monitoring and fetal biophysical profile are no more ideal tests because of their inability to detect early stages of fetal distress, significant number of false positive tests and low predictive value.

Pregnancy induced hypertension (PIH) is the most common medical complication during pregnancy. It is the leading cause of maternal and fetal morbidity and mortality. It has many complications. The most common complication of PIH is intra uterine growth retardation (IUGR). Others are placental infarcts, abruption. It is therefore desirable to know the accurate changes in uteroplacental and fetal circulation to predict perinatal outcome and help in appropriate intervention.

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It is here that role of Color Doppler comes. Hence study using color Doppler ultrasonography was planned to evaluate fetal outcome in normal and hypertensive pregnancies.

Methods

The present study of evaluation of fetal well being by blood flow studies was performed on 58 antenatal patients (with known LMP) in J.N. Medical College, A.M.U, Aligarh. Of the 58 patients 22 were normotensive and 36 hypertensive (at least 2BP recordings >139/90 with or without albuminuria). All the subjects underwent detailed clinical examination and relevant laboratory investigations .Study of various arteries was performed using Color Doppler ultrasound {TOSHIBA ECCO-CE CX} with 3.5 MHz curvilinear probe. Doppler measurements were taken with the mother in recumbent position during fetal inactivity and apnea.

Uterine artery was examined at the level of internal os with full bladder. Free floating loop of umbilical cord was examined to evaluate umbilical artery. Values at mid cord or placental insertion were taken as they were clinically reliable. Middle cerebral artery was located in a transverse section of fetal skull at the level of thalami and cavum septum pellucidum. Fetal aorta was examined in the transverse section at the level of diaphragm.

When 3 to 5 similar waveforms were imaged on screen, the required measurements were taken in the form of

- Peak systolic velocity
- End diastolic velocity
- Mean velocity

Calculation of indices: Following indices were calculated using the measurements from arterial waveforms.

1. S/D ratio
2. Resistive index: $RI = S - D/S$
3. Pulsatility index : $PI = S-D/$ mean value over one cardiac cycle

Where S = max. Systolic Doppler shift frequency
D = minimum Doppler shift frequency

Doppler indices were considered abnormal when S/D ratio, PI and RI of each artery > 2SD for the gestational age according to the standard reference values.

Results

Table 1. Maternal Characteristics of Study Population

Maternal characteristics	Normotensive	Hypertensive
Parity		
Primipara	12 (54.5%)	28(77.77%)
Multipara	10(45.5%)	08(22.23%)
Delivery		
Spontaneous vaginal	14(63.63%)	09(25%)
Induced	04 (18.18%)	01(2.78%)
Cesarean section	04(18.18%)	26 (72.22%)
Indication for CS		
Fetal distress	01(25%)	13(50%)
Severe pre-eclampsia	00	04(15.38%)
Others	03 (75%)	09(34.62%)
Perinatal outcome		
AGA	17(77.27%)	24(66.67%)
SGA	05(22.23%)	11(30.55%)
IUD	00	01(2.78%)

Table 2. Neonatal Characteristics

Neonatal characteristics	Normotensive	Hypertensive
Mean birth wt.	2.88	2.44
Mean gestational age	38.69	37.44
AGA	17/22(77.27%)	24/36 (66.67%)
SGA	05/22(22.73%)	11/36 (30.55%)
IUD	00	01/36 (2.78%)
Postnatal death	00	01/36(2.78%)

Table 3. Correlation of Abnormal Uterine Artery Blood Flow Indices with Baby Wt. and APGAR Score

	N	U/L ut. artery	B/L ut. artery	BABIES		Apgar score<7
				AGA	SGA	
Normotensive	22	4/22 (18.18%)	0	2/4 (50%)	2/4 (50%)	0
Hypertensive	36	12/36 (33.33%)	22/36 (61.11%)	23/34 (32.35%)	11/34 (67.65%)	3/34 (8.82%)

Table 4. Correlation of Abnormal Umbilical Artery Blood Flow Indices with Baby Wt. and APGAR Score

	N	Umbilical artery	BABIES		Apgar score <7
			AGA	SGA	
Normotensive	22	04/22 (18.18%)	1/4 (25%)	3/4 (75%)	O
Hypertensive	36	29/36 (80.56%)	18/29 (62.07%)	11/29 (37.93%)	3/29 (10.34%)

Table 5. Correlation of Abnormal Middle Cerebral Artery Blood Flow Indices with Baby Wt. and APGAR Score

	N	MCA		BABIES		Apgar score <7
		BSE	>2SD	AGA	SGA	
Normotensive	22	01/22	0	1/22	0/22	0
Hypertensive	36	28/36 (77.78%)	08/36 (22.22%)	25/36 (69.44%)	11/36 (30.56%)	3/36 (8.33%)

Table 6. Correlation of Abnormal Fetal Aorta Blood Flow Indices with Baby Wt. and APGAR Score

	N	Fetal aorta	BABIES AGA	SGA	Apgar score <7
Normotensive	22	03/22 (13.65%)	1/3 (33.33%)	2/3 (66.67%)	
Hypertensive	36	22/36 (61.11%)	11/22 (50%)	11/22 (50%)	3/22 (13.64%)

Table 7. Correlation of mean baby weight with number of arteries involved in AGA babies

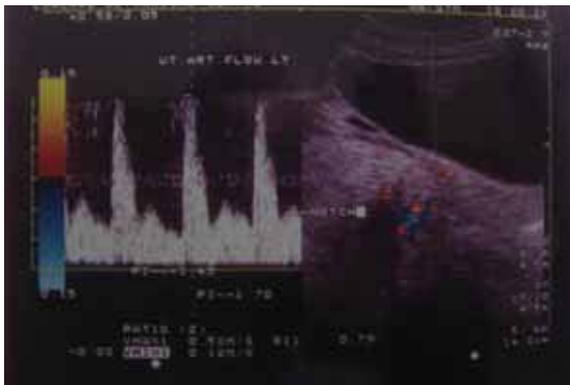| Group	n	No. of arteries involved	Mean baby weight
1	5	5	2.56
2	6	4	2.54
3	9	3	2.78
4	2	2	2.90
5	1	1	2.80

Fig1. A uterine artery flow velocity waveform with persistent diastolic notch in third trimester of pregnancy.
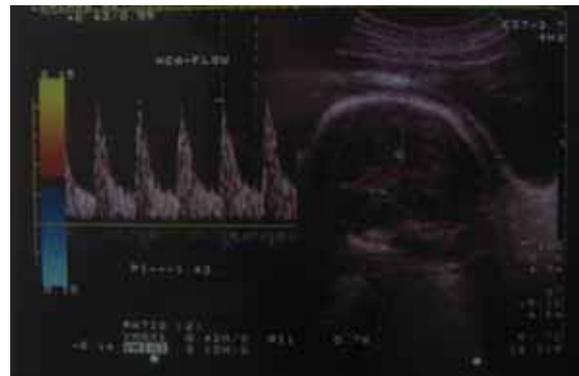

Fig 3. A middle cerebral artery flow velocity waveform showing brain sparing effect.

Fig 2. Reversed end diastolic flow can be seen in this umbilical artery flow velocity waveform.

Fig 4. A fetal aorta flow velocity waveform showing raised resistance.

In our study, 4 cases in normotensive group and 12 cases in hypertensive group showed u/l abnormal uterine artery indices while 22 cases in hypertensive cases showed b/l abnormal uterine artery indices. Among these cases, 2 cases in normotensive group and 11 cases in hypertensive group delivered small for gestational age (SGA) babies.

4 cases in normotensive group and 29 in hypertensive group showed abnormal umbilical artery indices. Among these cases, 3 in normotensive group and 11 in hypertensive group delivered SGA babies.

One case in normotensive group and 28 cases in hypertensive group showed brain sparing effect. Among these cases, all the babies were AGA in normotensive group while 11 babies were SGA in hypertensive group.

Three cases in normotensive and 22 cases in hypertensive group had shown abnormal fetal aorta blood flow indices. Among above 2 in normotensive group and 11 in hypertensive group delivered SGA babies. 3 cases in hypertensive group delivered babies whose Apgar score was below 7.

Discussion

There is increased maternal morbidity and mortality in hypertensive pregnancies. Since the traditional methods are not good enough to assess uteroplacental and fetoplacental circulation, blood flow studies are used to assess fetal well being in normal and hypertensive pregnancies. A total of 58 patients, 22 normal and 36 hypertensive pregnancies during the third trimester were studied in J.N. medical college, Aligarh.

The mean age of the patients varied between 19 to 33 yrs. In the hypertensive group, maximum number of patients was primigravida (77.77%). Among the total no. of 40 primigravida patients, 28(70%) were hypertensive. Mudalidar et al[1] also reported 70 % incidence of PIH in primigravida.

Blood Flow Studies
Uterine artery
Normal pregnancy: All three indices showed a gradual decline with increasing gestational age.

S/D ratio showed a gradual decrease from a mean of 2.2 at 28 wks to 1.6 at 40 weeks of gestation.

The mean value of RI also decreased from 0.55 at 28 weeks to 0.37 at 40 weeks.

The mean value of PI also fell from 0.73 at 28 weeks to 0.53 at 40 weeks.

Hypertensive pregnancies: All three indices showed a decline as in normal pregnancy, but the individual values at every gestational age are usually above 2 SD of the mean for that gestational age in the study group. 12 patients (33%) showed unilateral abnormal uterine artery indices while 22 patients (61.1%) showed bilateral abnormal uterine artery indices (Figure 1).

Haemodynamic changes occurring on the maternal side of placenta is reflected in uterine artery by 20 weeks of gestation. All three indices showed a gradual decline with increase in gestational age. In PIH, there is increased resistance in spiral arteries. This leads to increased impedance of blood flow in uterine artery. This is reflected in higher values of S/D PI and RI of the uterine artery. The abnormal waveforms were characterized by a higher systole, lower diastole and the persistence of diastolic notch which helps in predicting PIH. In present study, 34(94.44%) out of 36 hypertensive patients showed abnormal uterine artery flow of which 11 {32.35%} had IUGR and 1 IUD as fetal outcome. The results of the present study are comparable with other authors: Campbell et al.[2] Ferrier et al,[3] Zimmermann et al[4].

Umbilical artery

Normal pregnancy: The mean of all three indices showed a progressive decline with advancing gestational age due to decrease in umbilical artery resistance.

S/D Ratio decreased from a mean of 3.08 at 28 weeks to 2.1 at 40 weeks.

The mean value of RI also decreased from 0.67 at 28 weeks to 0.52 at 50 weeks.

PI value also fell from 1.02 at 28 weeks to 0.69 at 40 weeks of gestation.

Hypertensive pregnancies: In hypertensive pregnancies also, all the indices showed a decline in mean values with advancing gestational age but the individual value at every gestation was usually above 2SD for that gestational age in the study group. 29 patients (80.5%) had values above 2SD, one patient had absent end diastolic flow and one had revered end diastolic flow; (Figure 2) both had mortality of fetuses. Umbilical artery velocimetry correlates with haemodynamic changes in fetoplacental circulation. With increase in number of tertiary villi and arterial channels, fetoplacental compartment develops and the impedance in the umbilical artery decreases. The mean of all three indices showed a progressive decline with advancing gestational age due to decrease in umbilical artery resistance. But in IUGR first there is decreased diastolic flow in the umbilical artery due to increase in

the resistance that occurs in small arteries and arterioles of the tertiary villi. This raises the S/D ratio; PI and RI of the umbilical artery. As the placental insufficiency worsens, the diastolic flow decreases, then may become absent, and later reverses. In present study, 29 patients of 36 hypertensive patients had abnormal umbilical artery flow of which 11{30.5%} had IUGR as fetal outcome. These findings are comparable with findings of Beattie et al [5] Fiona et al[6]. In our study only one patient having severe hypertension had reversed end diastolic velocity (REDV) in umbilical artery and had sudden IUD. Another patient had absent end diastolic velocity (AEDV) and the baby expired 2 days after birth. Yoon et al [7] demonstrated in their study absent umbilical artery wave form is a strong and important predictor of adverse perinatal outcome.

Fetal Middle cerebral artery

Normal pregnancy: The mean value of all indices showed a progressive decline with increase in gestational age.

S/D ratio: There was a gradual decline in the mean value of S/D ratio from 6.28 at 28 weeks to 4.20 at 20 weeks.

The mean value of RI also decreased from 0.84 at 28 weeks to 0.75 at 40 weeks.

The mean value of PI also decreased from 2.09 at 28 weeks to 1.4 at 40 weeks.

Hypertensive pregnancies: All the indices gradually decreased with advancing gestational age and usually the values were below 2SD showing vasodilatation due to hypoxia. In our study, 28 (77.78%) patients showed brain sparing effect {BSE} and 8(22.2%) had values above 2 SD (Figure 3). Out of these, 11(30.5%) patients had small for gestational age (SGA) babies and 1(2.7%) had IUD. These findings are comparable with Marie et al [8] and Kirinken et al [9].

Fetal MCA is a low resistance circulation throughout pregnancy. The mean value of all indices showed decline with advancing gestational age due to decrease in impedance in MCA so as to meet the oxygen demands of the growing fetus. In IUGR, in response to chronic hypoxia, there is a redistribution of blood flow from non essential organs to the brain and myocardium. This adaptation is known as brain sparing effect. Several observational studies have explored cerebral redistribution {abnormal MCA Doppler indices and/or abnormal UA/MCA Doppler ratio} for the prediction of perinatal outcome in high risk pregnancies.

Fetal Aorta
Normal pregnancy

S/D ratio: There was a gradual decline in the mean values of S/D ratio from 6.6 to 5.3 at 40 weeks.

The mean value of RI decreased from 0.84 at 28 weeks to 0.81 at 40 weeks.

The mean value of PI decreased from 2.2 at 28 weeks to 1.77 at 40 weeks.

Hypertensive pregnancies: In hypertensive pregnancies 22(61.1%) cases showed values above 2 SD (Figure 4). Out of 22, 11(50%) patients had SGA babies. These findings are comparable with Nicholson et al [10].

These findings can be explained due to increase in placental resistance. Further increase in placental resistance may lead to reversal of flow in diastole.

Table 7 shows correlation of mean baby weight with number of arteries involved in appropriate for gestational age (AGA) babies.

Group 1: In 5 cases all the 5 arteries were involved (i.e. B/L uterine arteries, umbilical artery, MCA and fetal aorta). One patient had diastolic notch, 2 were TORCH positive and cord around the neck was detected in one patient. The mean baby weight of these patients was 2.56 kg.

Group 2: In 6 cases, 6 arteries showed abnormal indices. Here the mean baby weight was 2.54 kg. In 2 patients cord around the neck was detected by Doppler.

Group 3: There were 9 cases where the readings in 3 arteries were above 2 SD, 1 patient had diastolic notch and was TORCH positive and one had latent diabetes mellitus. Mean baby weight in this group was 2.91kg.

Group 4: There were 3 cases with 2 arteries involved. In one case, cord around the neck was detected by color Doppler. Here the mean baby weight was 2.91kg.

Group 5: One case had only one artery involved. The baby weight was 2.8 kg.

Out of 36 patients of PIH, 12 patients had involvement of all the 5 arteries. They delivered SGA infants with a mean weight of 1.92. Out of 12, 6 patients (15%) had abnormal biophysical profile, 5 patients had to undergo emergency caesarian section for fetal distress and one patient had a sudden IUD and one baby expired after 2 days.

Conclusion

The primary aim of antepartum surveillance is timely recognition of fetal compromise to enable appropriate intervention and to prevent further serious complications. Color Doppler can detect changes in fetomaternal and uteroplacental circulation which correlate strongly with the pregnancy outcome. Doppler velocimetry has proved to reliably predict any adverse fetal outcome in hypertensive pregnancies and aids in the appropriate timing of delivery. It helps us to take timely action, plan the treatment and also counsel the patients in future pregnancies.

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