

Blood Flow Studies in Evaluation of Fetal Well Being: A Study of Normal and Hypertensive Pregnancies.

Kusum Saxena, Sofia Haroon, Tamkin Rabbani, Sarosh Rana

Dept. of Obstetrics and Gynaecology, J. N. Medical College, A.M.U. Aligarh, U.P., 202 002

Summary

The objective of this study was to determine the role of blood flow studies in determining the fetal well being in normal and hypertensive pregnancies.

This is a prospective study conducted on pregnant women between 28-40 weeks gestation. Total 58 patients were recruited for the study. Out of these 22 were normotensive and 36 hypertensive. Blood flow study was done in 5 arteries – bilateral uterine arteries, umbilical artery, fetal middle cerebral artery and fetal aorta by colour doppler ultrasound. Fetal survival, baby weight and Apgar score at the time of delivery, were noted.

In patients with normotensive pregnancies, 78.28% delivered AGA (appropriate for gestation) babies and only 21.74% delivered SGA (small for gestation). Mean baby weight in this group was 2.88 kg, with no perinatal mortality. In patients in hypertensive group only 66.67% were AGA while 33.37% were SGA. The mean baby weight was 2.44 kg with 1 perinatal mortality.

Although, doubts have been raised about the cost effectiveness of colour doppler, abnormal doppler waveform detects fetal compromise at an early stage in patients with PIH and is thus helpful in providing optimal time for careful monitoring of the high risk fetus in utero and timely intervention in the form of delivery to reduce neonatal morbidity and mortality.

Introduction

Hypertension in pregnancy is associated with increased maternal and perinatal morbidity and mortality. It accounts for a total of 7.10% of perinatal mortality in developed countries and 20% in developing countries. The perinatal mortality is 5% in mild PIH and 15-25% in severe PIH (Ratnam S, 1992).

Hypertension in pregnancy predisposes the fetus to intrauterine death, dysmaturity, prematurity and IUGR. The timely diagnosis of fetal compromise by tests of fetal surveillance is very important so that, delivery can be effected before the fetus suffers irreversible damage or dies in utero. Blood studies by colour doppler ultrasound for evaluation of uteroplacental and

fetoplacental circulation is one of the most recent advancement of modern obstetrics. The purpose of this study is to evaluate the role of colour doppler in assessing the fetal well being in normal and hypertensive pregnancies.

Doppler waveform analyser yields information relating to the condition of proximal circulation and impedance of the distal vascular bed. The uterine arteries changes from a high resistance vessel with 1 or more diastolic notches into a low resistance vessel with no diastolic notch during pregnancy. Patients with abnormal uteroplacental flow velocity waveforms have a significantly high incidence of proteinuria, preterm delivery, C/S, low one minute Apgar score and low birth weight.

Abnormal umbilical artery S/D ratio alone or with abnormal uterine artery S/D ratio is associated with poor pregnancy outcome. Gudmundsson and Marshal (1988) stated that all variables studied in umbilical artery, PI, S/D and RI decrease with increasing gestational age and indicate decreasing placental vascular resistance.

Middle cerebral artery is a better indicator of fetal compromise. With increase in gestational age there is a fall in middle cerebral artery PI (Campbell et al 1990). SGA fetus with normal middle cerebral artery PI is at lower risk than the fetus with abnormal PI (Mari and Deter, 1992). In normal pregnancy, the waveform of blood flow in fetal intracranial artery has high S/D ratio resulting in high RI. Low S/D ratio has been found in neonatal asphyxia, occurring due to vasodilatation.

Thoracic aorta gives information about forward flow to body and placenta. Aortic flow velocity waveforms are most frequently abnormal than umbilical artery waveforms in patients with PIH and diastolic flow in descending aorta may be abnormal earlier than the umbilical artery blood flow.

Method:

The present study was conducted on 58 antenatal patients with known gestational age through last menstrual period, attending the antenatal clinics and admitted in the maternity ward of Department of Obstetrics and Gynaecology, Jawaharlal Nehru Medical College Hospital, A.M.U., Aligarh between February 1997 to August 1998.

Normotensive patients (control group) = 22
Hypertensive patients (study group) = 36 (atleast 2 B.P. recording of > 140/90 with or without albuminuria).

A complete history and thorough examination was done in all the patients. Blood flow studies of 5 arteries was done with the help of colour doppler (Toshiba Ecco-Cee Cx). The arteries studied were

- Bilateral uterine artery
- Umbilical artery
- Fetal aorta
- Fetal middle cerebral artery

- Uterine artery was examined at the level of internal os with full bladder using a transabdominal probe placed in either iliac fossa.
- Umbilical cord was located in the pool of amniotic fluid and values were taken at mid cord or placental insertion.

- Middle cerebral artery was localised in transverse section of fetal skull at the level of thalamus in the sylvian fissure.
- Recording of fetal aorta was taken at the level of diaphragm.

The indices measured were

$$- S/D \text{ ratio} = \frac{\text{Peak systolic doppler shift frequency (S)}}{\text{Least diastolic doppler shift frequency (D)}}$$

$$- \text{RI (Resistance index)} = \frac{S - D}{S}$$

$$- \text{PI (Pulsatility index)} = \frac{S - D}{\text{mean}}$$

Observations

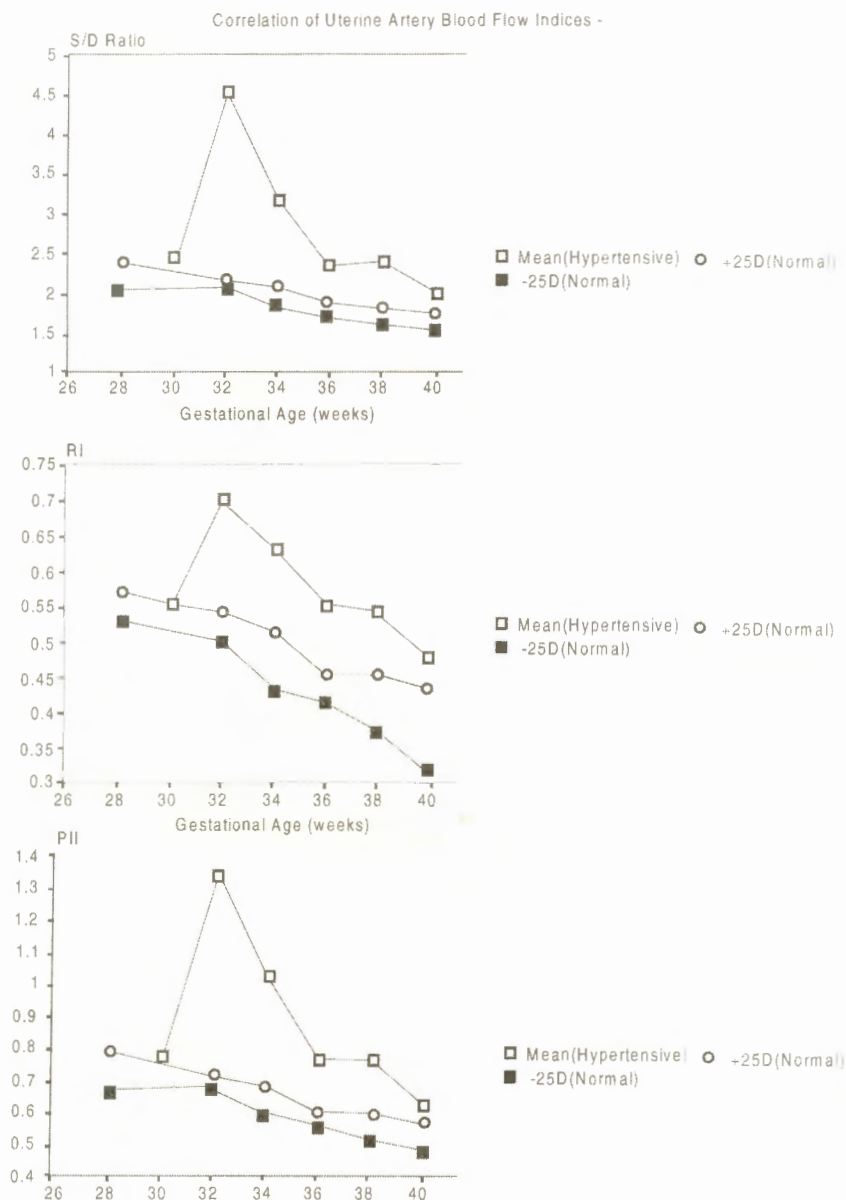
1. In the present study age varied from 19-33 years.
2. Parity varied from P₀-P₃.
3. Gestational age on inclusion in the study group varied from 28-40 weeks.
4. Gestational age at time of delivery varied from 32-40 weeks.
5. Examination delivery interval varied from < 1 week to 9 weeks.
6. In the study group the maximum number of deliveries occurred in < 1 week of normal doppler study while in the control group most of the patients delivered near term.
7. The mean values of all indices in all the vessels studied i.e., S/D ratio, RI and PI reduced with advancing gestation.
8. The table-1 shows uterine artery indices in normal and hypertensive pregnancies.
 - a) All indices shows a gradual decline with increasing gestational age, in both normal and hypertensive patients.
 - b) In hypertensive pregnancies, although there is a decline in the indices but the values are usually above 2SD of mean for that gestational age, which is a manifestation that the vascular tone has not changed in these patients i.e. normal adaptation to pregnancy has failed to occur.
 - c) Abnormal RI ratio and persistence of diastolic notch in uterine artery is important in patients with high risk for PIH.
 - d) PI also showed a decreasing trend with increasing gestation. PI is of speical use in hypertensive pregnancy, where diastolic flow is zero or in reverse direction.

Table - I
Uterine Artery Indices

G.A.	S/D		RI		PI	
	Normal	Hyp.	Normal	Hyp.	Normal	Hyp.
28	2.20±0.16	-	0.55±0.02	-	0.73±0.06	-
30	-	2.41±1.18	-	0.55±0.39	-	0.77±0.36
32	2.10±0.04	4.47±3.92	0.52±0.02	0.69±0.24	0.70±0.02	1.34±0.88
34	1.92±0.12	3.12±2.84	0.47±0.04	0.62±0.23	0.64±0.04	1.02±0.90
36	1.76±0.10	2.29±0.69	0.43±0.02	0.54±0.11	0.58±0.02	0.76±0.22
38	1.68±0.10	2.34±1.42	0.41±0.04	0.53±0.23	0.56±0.04	0.77±0.45
40	1.60±0.10	1.86±1.48	0.37±0.06	0.47±0.11	0.53±0.04	0.63±0.13

GA=Gestational age, Hyp. = Hypertensive

Figure I



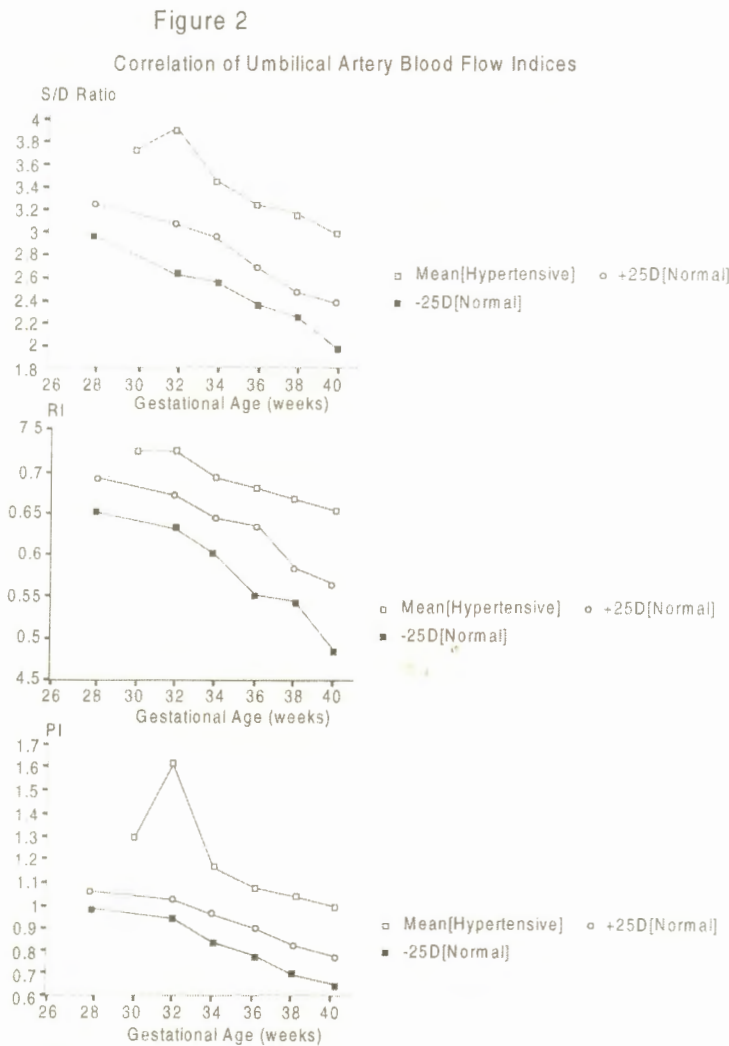
9. The Table – II shows, umbilical artery indices in normal and hypertensive pregnancies.
- The mean of all the indices showed a progressive decline with advancing gestation in both normal and hypertensive pregnancies.
 - In patients with hypertension the value are usually above 2SD for that gestational age.

S/D ratio is important in umbilical artery as it is a vessel of high diastolic flow, and measurement of S/D ratio is valuable for fetal surveillance if done serially in patients with high risk for developing complications such as PIH and IUGR.

Table – II
Umbilical Artery Indices

G.A.	S/D		RI		PI	
	Normal	Hyp.	Normal	Hyp.	Normal	Hyp.
28	3.08±0.14	-	0.67±0.02	-	1.02±0.04	-
30	-	3.69±0.34	-	0.72±0.03	-	1.29±1.02
32	2.85±0.18	3.85±2.70	0.65±0.02	0.72±0.20	0.98±0.04	1.61±1.32
34	2.70±0.20	3.40±1.90	0.62±0.02	0.69±0.18	0.89±0.06	1.150±0.62
36	2.46±0.16	3.18±1.08	0.59±0.04	0.67±0.10	0.82±0.06	1.06±0.36
38	2.29±0.10	3.09±0.96	0.56±0.02	0.66±0.10	0.76±0.04	1.02±0.28
40	2.10±0.20	2.91±0.94	0.52±0.04	0.65±0.10	0.69±0.06	0.97±0.32

GA=Gestational age, Hyp. = Hypertensive



10. The table – III shows the fetal aorta blood flow indices

- a) Fetal aorta indices give information about the forward flow in the body and most indices show only a slight decrease in the second half of pregnancy.
- b) In hypertensive patients, most of the values

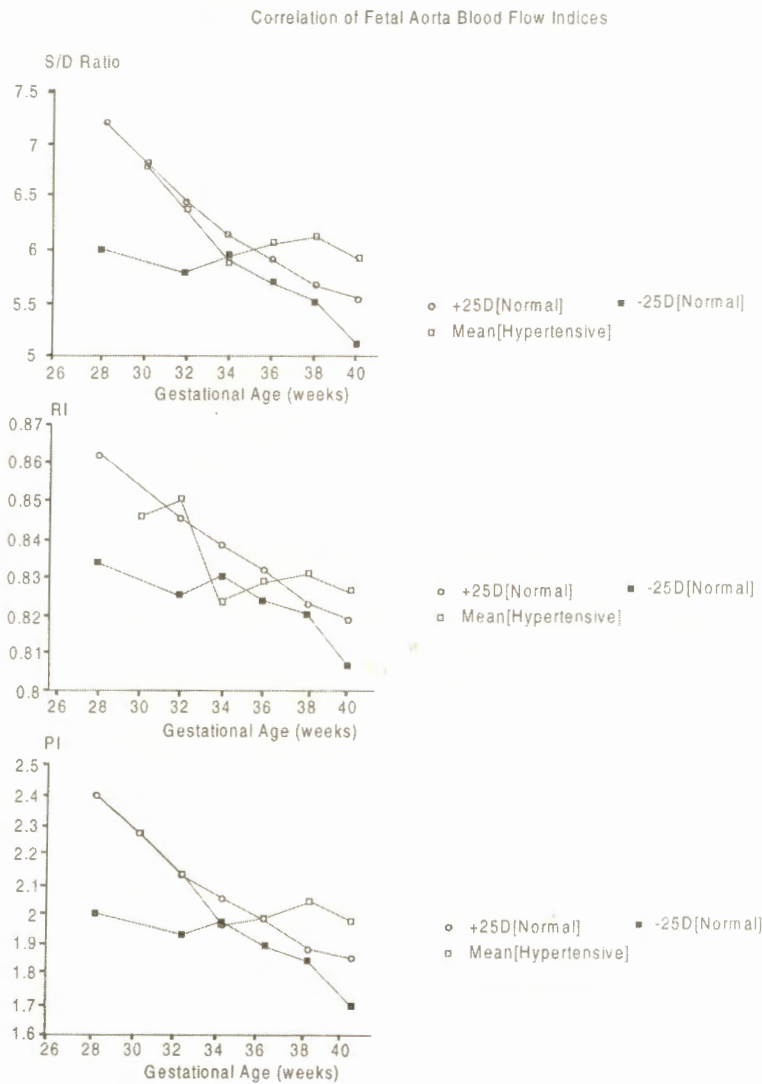
are above 2SD for that gestational age, this is because of increased peripheral resistance. The peripheral resistance may be increased to an extent that forward is not achieved through out the entire cycle. When the diastolic flow is zero, S/D reaches infinity and RI is 1. In these cases calculation of PI is important.

Table – III

G.A.	S/D		RI		PI	
	Normal	Hyp.	Normal	Hyp.	Normal	Hyp.
28	6.6±0.60	-	0.84±0.02	-	2.20±0.20	-
30	-	6.79±1.91	-	0.84±0.05	-	2.27±0.65
32	6.10±0.34	6.37±1.87	0.84±0.01	0.85±0.13	2.03±0.10	2.13±0.64
34	6.03±0.10	5.87±0.84	0.83±0.01	0.82±0.02	2.01±0.04	1.95±0.98
36	5.79±0.12	6.04±1.31	0.82±0.05	0.82±0.03	1.93±0.04	1.98±0.44
38	5.59±0.08	6.13±1.35	0.81±0.01	0.83±0.03	1.86±0.02	2.04±0.45
40	5.53±0.22	5.91±0.54	0.81±0.01	0.84±0.02	1.77±0.08	1.97±0.20

GA = Gestational age, Hyp. = Hypertensive

Figure 3



11. The Table IV shows the middle cerebral artery indices in normal and hypertensive pregnancies.

- a). The mean value of all indices shows a progressive decline with advancing gestational age due to decrease in vascular resistance in middle cerebral artery so as to meet the oxygen demands of the growing fetus.
- b). PI index is more important in middle cerebral artery, as this is a vessel of high resistance

with low end diastolic flow.

- c) In hypertensive patients also, the value of the indices decrease with advancing gestation but the values are below 2SD for a given gestational age, which is due to vasodilatation occurring due to hypoxia. This is known as brain sparing effect. As hypoxia worsens, vasoconstriction occurs due to development of cerebral edema.

Table IV
Middle Cerebral Artery Indices

G.A.	S/D		RI		PI	
	Normal	Hyp.	Normal	Hyp.	Normal	Hyp.
28	6.28±0.14	-	0.84±0.01	-	2.09±0.04	-
30	-	5.46±4.28	-	0.79±0.20	-	1.82±1.44
32	5.90±0.52	4.69±2.52	0.83±0.02	0.79±0.08	1.96±0.16	1.63±0.71
34	5.43±0.10	4.48±2.18	0.81±0.02	0.76±0.12	1.81±0.04	1.49±0.72
36	5.18±0.16	4.24±1.57	0.80±0.02	0.72±0.10	1.72±0.06	1.42±0.53
38	4.62±0.10	4.29±2.48	0.76±0.04	0.74±0.15	1.55±0.02	1.41±0.81
40	4.20±0.10	3.27±2.15	0.75±0.02	0.64±0.27	1.41±0.02	1.09±0.72

GA - Gestational age, Hyp.= Hypertensive

Figure 4

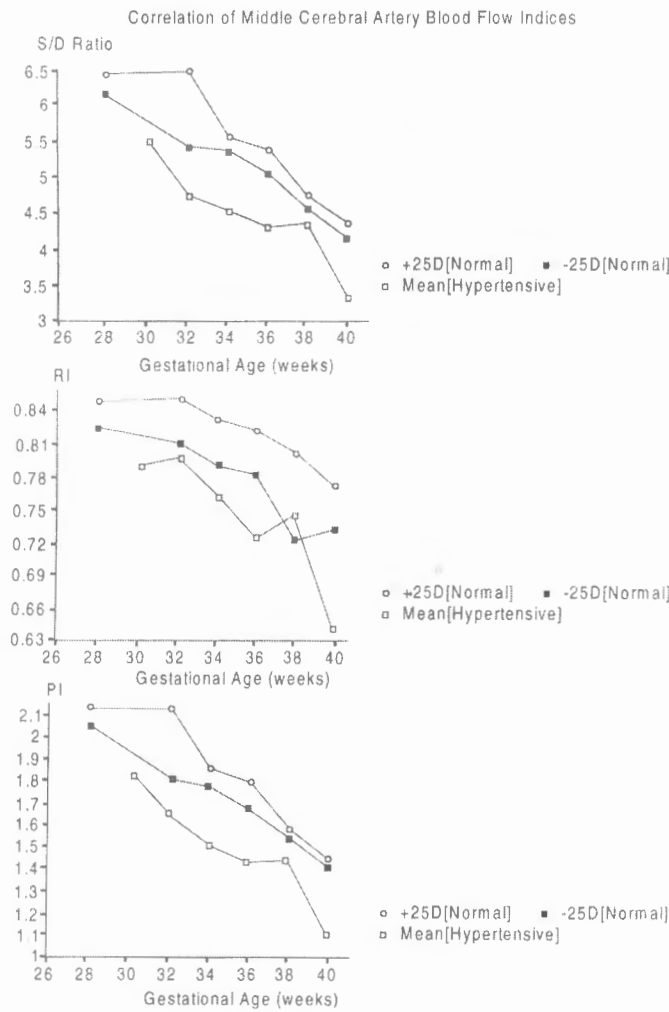


Table V

	Normotensive Patients, n=22		Hypertensive Patients, n = 36	
	AGA N=18 (78.28%)	SGA n=5 (21.74%)	AGA n=24(66.66%)	SGA n=12(33.33%)
RUT	0	1(20)	16(66.66)	12(100)
LUT	1(5.5)	2 (40)	15(62.5)	12(100)
UMB	1(5.55)	3(60)	17(70.83)	12(100)
MCA				
BSE	0	1(20)	22(91.66)	6(50)
Abn.	0	0	2(8.33)	6(50)
FA	1(5.55)	0	11(45.83)	11(91.66)
Av.BW	3.038 kg	2.18 kg	2.65 kg	1.928 kg
A/S				
9/10	18(100)	5(100)	24(100)	8 (66.66)
6/10	-	-	-	1(8.33)
4/10	-	-	-	2(16.66)
ND	0	0	0	1(8.33)

AGA = appropriate for gestation, SGA = small for gestation, RUT = right uterine artery, LUT = left uterine artery, UMB = umbilical artery, MCA middle cerebral artery, BSE = brain sparing effect, Abn. = abnormality, FA = fetal aorta, Av. BW = average birth weight, A/S = apgar score, ND = neonatal death.

The table V shows data of 22 normotensive patients and 36 hypertensive patients. In the normotensive group, 78.28% babies delivered were AGA while 21.74% were SGA. Among patients delivering AGA babies, 1 patient (5.55%) had abnormality in LUT, 1 patient (5.55%) had abnormality in UMB and 1 patient (5.55%) had abnormality in FA. The average baby weight was 3.038 kg and all patients delivered babies with A/S >8/10. In the normotensive SGA group, there were 5 deliveries. One patient (20%) had abnormality of RUT, 2 patients (40%) had abnormality of LUT, 3 patients (60%) had abnormality of UMB and 1 patient (20%) had Brain sparing effect. The average weight in this group is 2.18 kg. while all neonates had A/S >8/10.

In the hypertensive group, there were 66.66% of AGA and 33.33% were SGA. Among the AGA group, 16 patients (66.66%) had abnormality of RUT, 15 patients (62.5%) had abnormal waveform in LUT, 17 patients (70.83%) in UMB, 22 patients (91.66%) showed brain sparing effect while 2 patients (8.33%) had abnormality in middle cerebral artery waveform and 11 patients (45.83%) had abnormality of FA. The average baby weight in this group was 2.05 kg. And all neonates had A/s >8/10. In the group of SGA, out of 12 patients, all (100%) had abnormality of RUT, LUT, UMB. Only 50% patients showed Brain sparing effect while 50% showed abnormality of middle cerebral artery. 11 patients (91.66%) had abnormality of FA. The average weight in this group was 1.928. Only 66.66% of babies in this group had A/S >8/10, 8.33% had A/S of 6/10 while

16.66% had A/S of 4/10. There was one neonatal death in this group.

Discussion :

1. Correlation of uterine artery indices:

All indices showed a gradual decline with increasing gestational age. There is uncoiling of main uterine and spiral arteries during second trimester which causes increase in diastolic flow and reduction in the value of various indices. S/D ratio is important in uterine artery as there is abundant diastolic flow. The decrease in S/D ratio reflects the adequacy of uteroplacental circulation and hence the fetoplacental circulation. The mean value of RI and PI also decreases with increasing gestation. Abnormal RI ratio indicates increased resistance and is important in high risk patient. PI index is also important in complicated pregnancies where diastolic flow becomes zero as in these cases S/D ratio becomes infinite and RI becomes one.

Seen in Table-I and Figure -1, In hypertensive pregnancies, there is a fall in indices with increasing gestation but the values are higher than 2SD in comparison to patients who were normotensive. These high values are a manifestation of unaltered vascular tone or spasm, in other words normal adaptation to pregnancy has not occurred. These findings are consistent with Pearce et al (1983) and

Shulman et al (1986)

2. Correlation of Umbilical artery indices:

As seen in Table-II and Figure-2, the mean of all the indices shows a gradual decline with advancing gestational age due to decrease in umbilical artery resistance. The development of small arteries and arterioles of tertiary villi are responsible for major drop in arterial resistance across the umbilical placental vascular bed which is important to maintain an adequate fetoplacental circulation to fulfill the demands of the growing fetus.

In hypertensive pregnancies, the indices showed a gradual decline in mean values but the individual values at each gestational age is above 2SD. The high values in hypertensive patients represent failure of angiogenesis resulting in increased resistance. These findings are consistent with Stuart (1980), Shulman et al (1984), Vugt et al (1987) and Saxena et al (1996).

3. Correlation of Fetal aorta indices:

Fetal aorta has a high systolic velocity with low end-diastolic flow, as it is a high resistance vessel. There is a gradual decline in mean values of all indices in normal and hypertensive pregnancies (Table-III and Figure-3), but in hypertensive pregnancies the individual values were above 2SD for a given gestational age. Flow abnormalities in hypertensive patients are in the form of reduced diastolic flow resulting in higher values due to increase in peripheral resistance owing to peripheral vasoconstriction. These findings are consistent with Bilardo et al (1988) and Arstrom et al (1989).

4. Correlation of Middle cerebral artery indices:

As seen in Table-IV and Figure-4, the mean values of all indices in normotensive patients, showed a progressive decline with advancing gestational age due to decrease in vascular resistance in middle cerebral artery, so as to meet the oxygen demands of growing fetus. PI index is very important in middle cerebral artery as this is the vessel of high resistance with low end diastolic flow. PI shows a gradual decline with increasing gestation in normotensive patients.

In hypertensive patients, all indices gradually declined with advancing gestation and the values are below 2SD showing vasodilatation due to hypoxia. This is known as brain – sparing effect.

These findings are consistent with Kirkmen (1987) and Arstrom et al (1989).

5. Correlation of Abnormal waveform with Birth weight and Neonatal morbidity and mortality:

As seen in Table-V, in normotensive patients 78.28% delivered AGA while 21.74% delivered SGA. Among 18 patients who delivered AGA, only 1 patient (5.55%) had abnormality in UUT, UMB and FA. The average birth weight in this group was 3.038kg. In comparison to this, out of 5 patients who delivered SGA as many as 3 patients (60%) showed abnormal waveform in UMB, 2 patients showed abnormality in UUT and 1 patient showed abnormality in RUT while 1 patient even showed brain sparing effect. The average fetal weight in this group was 2.18kg, which is much less as compared to the previous group. Both these groups of normotensive patients had no neonatal morbidity and mortality.

This is in contrast to hypertensive patients. In this group out of total 36 patients only 66.66% delivered AGA while 33.33% delivered SGA. Among patients who delivered AGA, 22 patients (91.66%) showed brain sparing effect with 17 patients (70.83%) showing abnormality of UMB, 16 patients (66.66%) showing abnormality of RUT and 15 patients (62.5%) showing abnormality of UUT. The average fetal weight in this group was 2.65 kg and there was no neonatal morbidity and mortality.

Among hypertensive patients who delivered SGA, all patients (100%) showed abnormality of UUT, RUT, UMB and 91.66% showed abnormality of FA. Only 50% of the patients had brain sparing effect (as compared to 91.66% in patients delivering AGA) and another 50% showed abnormality of MCA. The average fetal weight in this group was 1.928 kg, which is least among all groups. Also there was severe birth asphyxia seen in 16.66% of babies and mild birth asphyxia in 8.33% of babies. There was 1 neonatal death in this group.

Conclusion:

Colour doppler study of various arteries, indicating their flow pattern during pregnancy is an important yard stick for the obstetricians when dealing with complicated pregnancies such as those associated with PIH and IUGR. Abnormal flow indices are seen in these patients. Also abnormality in blood flow indices directly correlates with the neonatal outcome in the form of baby weight, Apgar score and neonatal morbidity.

Thus colour doppler can be used as an important diagnostic aid which can detect fetal compromise at an early stage and help in adequate management of patients before the fetus suffers irrevocable damage or dies in utero.

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