

thereby uncoiling the main uterine and spiral arteries. Between 26 and 28 weeks of gestation, uterine arteries reach their maximal dilatation and minimal resistance [6-37].

The uteroplacental flow increases throughout pregnancy from approximately 50 ml/min during early pregnancy up to 450-600 ml/min near term. During normal pregnancy, the trophoblastic cells enter the lumen of the spiral arteries, partially replacing the endothelium and progressing down up to the level of the endometrium. By 16-22 weeks gestation, trophoblasts migrates along the entire length (intramyometrial portion) of the spiral arteries and strips it of its muscular elastic coat [38].

This transformation leads to formation of a low resistance vascular system, progressing from the radial artery into the intervillous spaces; the pressure falls about 70 to 80 mm Hg in the former to 10 mm Hg in the latter. In fetoplacental circulation during fetal life oxygenation is carried out in placenta. The tortuous umbilical cord is the lifeline of fetus. It has two umbilical arteries and one umbilical vein. A considerable amount of oxygenated blood returning from the placenta through the umbilical vein is directed through the ductus venosus to the inferior vena cava into the right atrium, through the foramen ovale, this oxygenated blood is directed to the left atrium and then to the left ventricle. Blood from the right ventricle is ejected either into the pulmonary circulation or through the ductus arteriosus into the descending aorta.

The blood returns to the fetus by the umbilical vein, emptying into the portal sinus. Then the major portion of the blood passes through ductus venosus to inferior vena cava, just before it enters into the right atrium. Blood flow through the fetal heart is "parallel" rather than "serial" because of the presence of ductus arteriosus between the pulmonary trunk and the aorta. Both the ventricles eject blood into the aorta simultaneously rather than blood moving first through the right ventricle, then the pulmonary circulation, and finally the left ventricle as in the adult. The blood returns to the fetus by the umbilical vein, emptying into the portal sinus. Then the major portion of the blood passes through ductus venosus to inferior vena cava, just before it enters into the right atrium. About 50% of inferior vena caval blood passes directly through the foramen ovale into the left atrium to mix up with pulmonary blood and then enters the left ventricle. Well oxygenated blood from the left ventricle is directed through the ascending aorta to supply the coronary arteries and the upper body organs, thus preferentially perfusing the brain. This blood enters pulmonary artery, which is in direct continuity with descending aorta via ductus arteriosus and perfuses the lower body and placenta.

The fetal cerebral blood flow is of a high impedance, low flow circulation. It is a more sensitive parameter of fetal oxygenation status than umbilical blood flow. The increase in the diastolic component as the pregnancy progresses is interpreted as decrease in cerebral resistance due to brain development. This increase in

diastolic component begins later in the cerebral arteries (at approximately 25 weeks) than in umbilical arteries (approximately 15 weeks) [39-46].

MATERIALS AND METHODS

This is a prospective study conducted on hundred patients with clinically diagnosed pregnancy induced hypertension for the evaluation of the effectiveness of Doppler studies in hypertension complicating pregnancy with relevance to perinatal outcome undertaken at Sree Balaji Medical College and Hospital, Chromepet, Chennai, in the Department of Obstetrics and Gynaecology, during the period from August 2010 to September 2012.

Inclusion criteria

All antenatal cases more than 26 weeks of gestation clinically diagnosed as pregnancy induced hypertension.

Exclusion criteria

- All antenatal cases with chronic hypertension.
- All antenatal cases less than 26 weeks of gestation clinically diagnosed as pregnancy induced hypertension.
- All antenatal cases with abnormal Doppler findings without pregnancy induced hypertension.
- Intrauterine death at the time of first Doppler examination.
- Patients who cannot be followed up.

The first scan was performed in each case, as soon as the patient was registered in order to avoid any influence of treatment on Doppler sonogram. The gestational age was confirmed by menstrual history and ultrasound examination and was followed by color Doppler examination. Consent was taken from the patient or the guardian.

Method of study

In all patients, a thorough general and obstetric history was elicited and a complete general and obstetric examination was done. All the patients were monitored and for four hourly blood pressure recordings, daily urine analysis, twice weekly blood urea and uric acid and fundus examination. Liver function tests, platelet count, electrolytes, complete hemogram were done once in a week. These investigations were repeated as and when necessary till delivery. Fetal surveillance was done with daily fetal movement count, twice weekly NST and modified Biophysical profile. Further management was done depending upon the severity of preeclampsia and condition of the cervix. USG and Doppler flow velocimetry of umbilical, uterine artery and middle cerebral artery were studied at term, and the mode of delivery, fetal outcome were studied documented and analysed.

Doppler study was performed in a prospective study. In the obstetric examination, uterine fundal height and abdominal girth were measured. Fetal heart rate counted.

IUGR was diagnosed if there is > 2cm difference in Symphysis fundal height to the clinical gestational age.

Procedure

The patient was explained about the non-invasive/atraumatic nature of the procedure. Synthetic ultra-gel was applied liberally over the abdomen to get a good acoustic coupling. The instruments used were Hitachi EUB 5500, Hitachi EUB 7000, Philips Envisor HD C-1.3 Color Doppler ultrasound machine with a convex transducer of 2-5: Ml-Iz frequency. Doppler wave form was obtained after localising the vessels by B-mode real time scanner. Pulsed Doppler was used to get the Doppler signals after localising 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 fetal respiration on Doppler signals.

Identification of various arteries and their criteria

Uterine artery

Color Doppler facilitates identification of the uterine artery substantially. The uterine signal was obtained per abdomen by pointing the probe in the iliac fossa towards the lower para-cervical area. In the color mode, the uterine artery is seen to cross the external iliac artery, just after its origin from the internal iliac artery and this point were taken as the sampling point. SID >2.6, RI > 0.58 and persistent early diastolic notch is considered abnormal.

Umbilical artery

Flow velocity waveforms from umbilical artery can be easily obtained, for this color flow is not usually needed. Doppler signals can be acquired from different points in cord, usually from midportion of cord. SID ratio of umbilical artery >3, RI>0.7, presence of absent end diastolic velocity (AEDV) and reversed end diastolic velocity (REDV) were considered abnormal.

Table 1: Age distribution of cases.

Age group (years)	No. of cases	Percentage (%)
<20	6	6
20-24	39	39
25-29	35	35
30	20	20
Total	100	100

Table 2: Gravidity and gestational hypertension.

Gravidity	No. of cases	Percentage (%)
Primi	59	59
Gli	20	20

Middle cerebral artery (MCA)

MCA was visualized in transverse axial view of fetal head at a slightly more caudal plane than the one used for BPD. PI <1.3 and RI <0.7 were considered abnormal.

Follow up of cases

Maternal indications for termination of pregnancy included uncontrolled hypertension, abruption, deteriorating renal function and HELLP syndrome.

Fetal indications for termination - Evidence of fetal distress either by Biophysical profile or abnormal CTG.

The mode of delivery, Gestational age at delivery, whether delivery was Induced or spontaneous were noted. If induced, indication for Termination/mode of delivery-Labor Natural/elective/emergency LSCS were noted. The following were taken as adverse perinatal outcome.

- Preterm delivery.
- Birth weight < 10th percentile below the mean for gestational age.
- APGAR at 5 minutes < 7/10.
- Caesarean section done for fetal distress.
- Admission to NICU.
- Presence of Respiratory Distress, Hypoxic ischemic encephalopathy, intraventricular haemorrhage, Necrotising enterocolitis, seizures.
- Perinatal deaths.

RESULTS

In the present study, out of 100 cases of Hypertension Complicating Pregnancy, 58 cases showed positive Doppler indices in any of the three vessels studied. The remaining 42 cases showed normal Doppler indices in all the three vessels studied. The following were the results of the study. From our present study, age group 20-24 years was the common group. The mean maternal age was 25.46 years (Table 1). In the present study, 59 % were primigravitas, 41% were multigravidas (Table 2).

G III	11	11
GIV&V	10	10
Total	100	100

Out of the 100 cases studied 46% constituted gestational hypertension cases. Mild preeclampsia was seen in 28% of the cases, while severe preeclampsia is seen in 24% of the cases. Eclampsia occurred in 3% of cases. A widely quoted study by Friedman and Neff (1976) showed that

diastolic hypertension of >95 mmHg was associated with 3 fold increase in fetal death (Table 3).

Table 3: Type of hypertension complicating pregnancy.

Type	No. of Cases	Percentage (%)
Gestational hypertension	46	46
Mild preeclampsia	28	28
Severe preeclampsia	24	24
Eclampsia	3	3
Total	100	100

After studying three arteries, patients were classified into normal and abnormal based on their color Doppler indices. Normal was those with no abnormality in any of the arteries (Table 4). Cases that had any of the following criteria were considered abnormal:

- SID ratio >2.6 or RI >0.58 of Uterine Artery.
- Presence of persistent Early Diastolic Notch in Uterine Artery.

- SID ratio of >3 or RI 0.7 of Umbilical Artery.
- Presence of Absent End Diastolic Velocity (AEDV) of Reversed End Diastolic Velocity (REDV).
- PI <1.3 and RI <0.7 of Middle Cerebral Artery.

In present study, 58 cases (58%) had abnormal Doppler indices (Table 5).

Table 4: Other complications coexisting.

Type of complication	No. of cases	Percentage
Anaemia	18	18
Oligohydramnios	28	28
Accidental Haemorrhage	6	6
Eclampsia	3	3
Rh-negative	2	2

Table 5: Normal and abnormal doppler wise distribution of cases.

Doppler	Number	Percentage (%)
Normal	42	42
Abnormal	58	58
Total	100	100

The table shows more than 50% of cases with elevated SID ratio (Table 6 and Figure 1). The table shows 74% of cases with abnormal RI in this study (Table 7 and Figure

2). About 72% of the cases had normal umbilical artery SID ratio (Table 8 and Figure 3).

Table 6: Uterine artery SID ratio.

SID ratio	No. of cases	Percentage
Abnormal	33	56.9
Normal	25	43.1

Total	58	100
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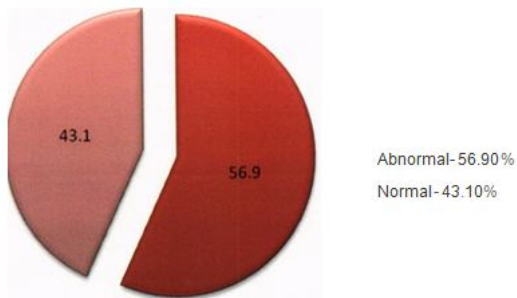


Figure 1: Uterine artery SID ratio.

Table 7: Uterine artery resistance index.

Resistance Index	No. of cases	Percentage
Abnormal	43	74.14
Normal	15	25.86
Total	58	100

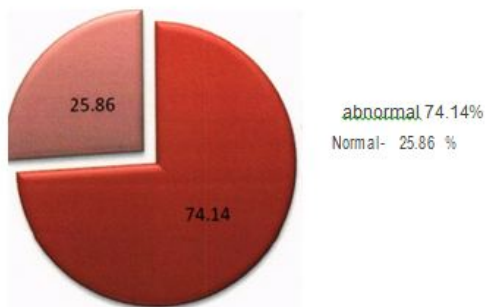


Figure 2: Uterine artery resistance index.

Table 8: Umbilical artery SID ratio.

Umbilical artery SID ratio	No. of cases	Percentage
Abnormal	42	72.41
Normal	16	27.59
Total	58	100

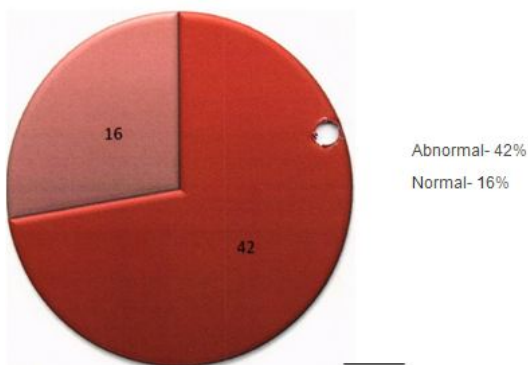


Figure 3: Umbilical artery SID ratio.

Nearly two-third of cases with abnormal doppler show abnormal umbilical artery RI value (Table 9 and Figure 4). In the present study, 8 cases (about 13%) showed absent end diastolic velocity in umbilical artery (Table 10). Uterine artery SID X2 -1.1., umbilical artery X2-nl l. 66., uterine notch X2-1.72 (p<0.01) (Table 11).

Table 9: Umbilical artery resistive index.

Umbilical artery RI	No. of cases	Percentage
Abnormal	36	62.06
Normal	22	37.94
Total	58	100

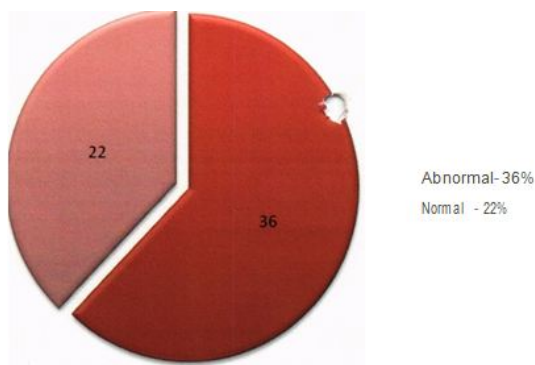


Figure 4: Umbilical artery resistive index.

Table 10: Umbilical artery AEDV.

Umbilical artery AEDV	No. of cases	Percentage
Present	8	13.79
Absent	50	86.21
Total	58	100

Table 11: Cases with doppler abnormality.

Parameters	SID Ut.A		SID Um.A		Notch		AEDV	
	No.	%	No.	%	No.	%	No.	%
Abnormality present	33	56.9	42	72.41	24	41.38	8	13.79
Abnormality absent	25	43.1	16	27.59	34	58.62	50	86.21
Total	58	100	58	100	58	100	58	100

Of the 58 women with abnormal Doppler indices, 55 babies born to them had adverse perinatal outcome in terms of neonatal complications which included birth asphyxia, Meconium aspiration syndrome, hyperbilirubinemia, Respiratory distress syndrome, etc. of the mentioned neonatal complications, majority of them had hyperbilirubinemia-18/55, while it was only 8 babies abnormal Doppler indices had hyperbilirubinemia (Figure 5 to Figure 13).

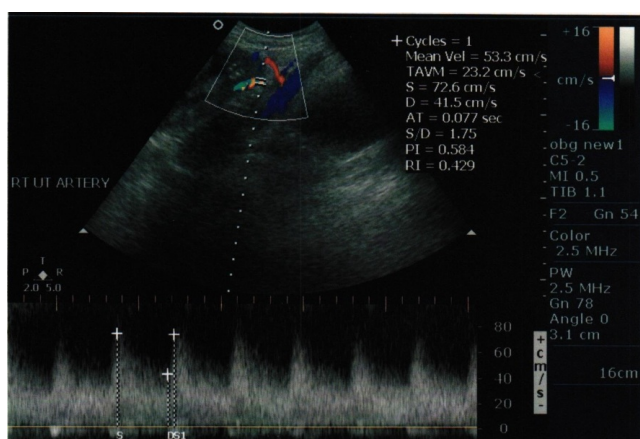


Figure 5: Color and pulse doppler imaging of right uterine artery showing normal doppler parameters.

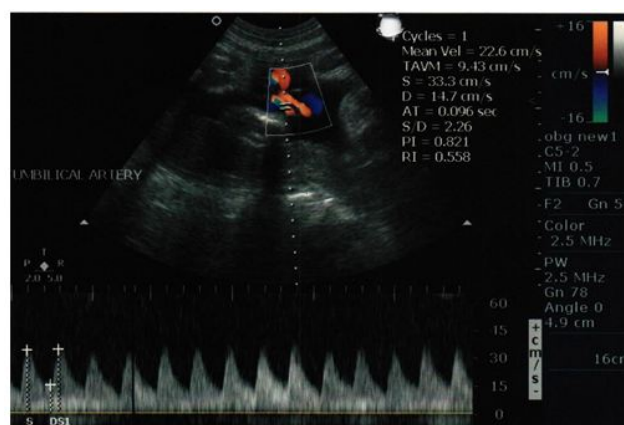


Figure 6: Colour and pulse doppler imaging of umbilical artery showing normal doppler parameters.

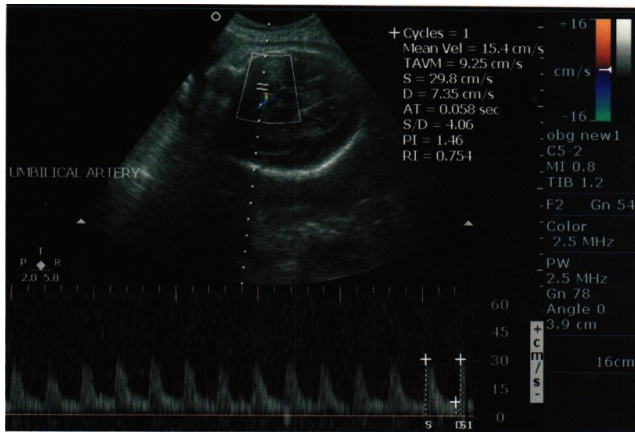


Figure 7: Color and pulse Doppler imaging of middle cerebral artery showing normal Doppler parameters.

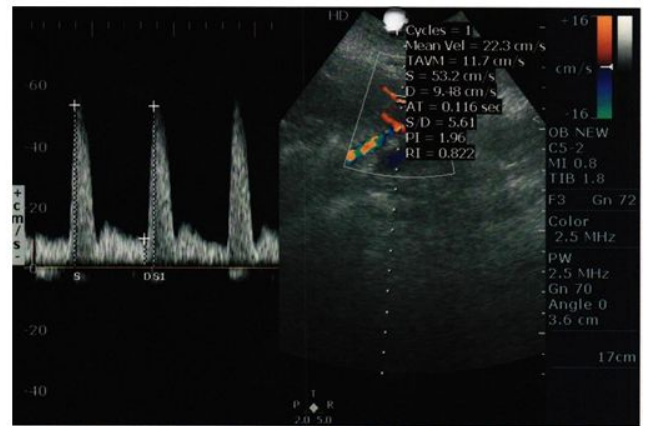


Figure 10: Color and pulse Doppler imaging of right uterine artery showing persistent early diastolic notch with raised RI and SID ratio.

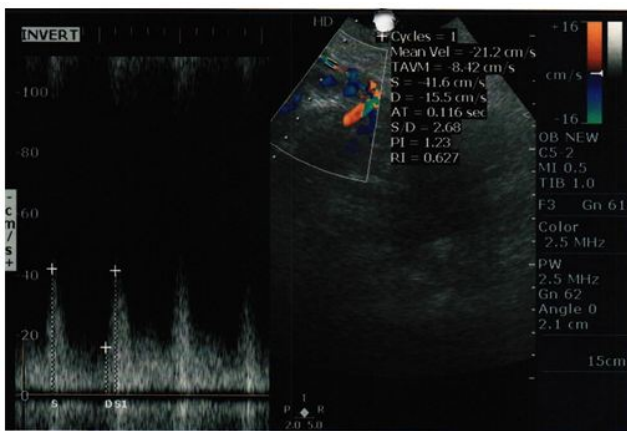


Figure 8: Color and pulse Doppler imaging of right uterine artery showing raised RI and SID ratio.

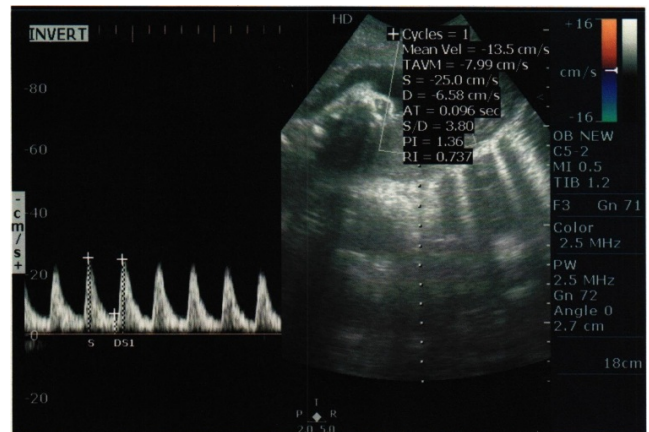


Figure 11: Color and pulse Doppler imaging of umbilical artery showing reduced diastolic flow with raised RI and SID ratio.

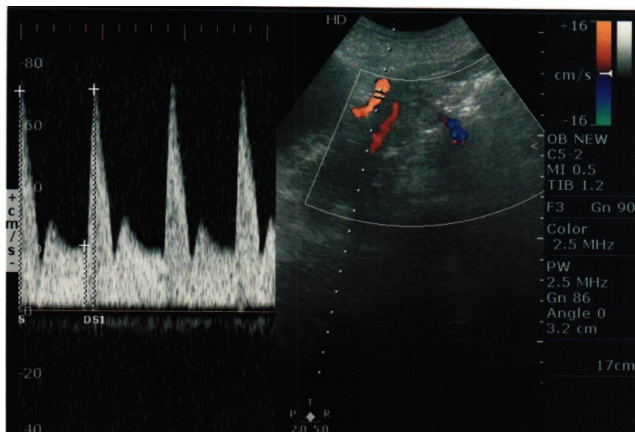


Figure 9: Color and pulse Doppler imaging of right uterine artery showing persistent early diastolic notch.

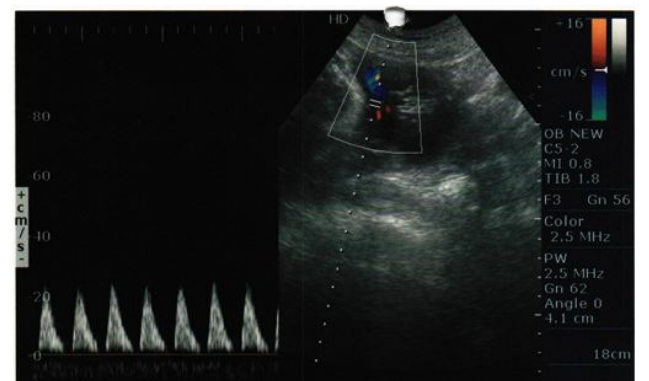


Figure 12: Color and pulse Doppler imaging of umbilical artery showing absent end diastolic flow.

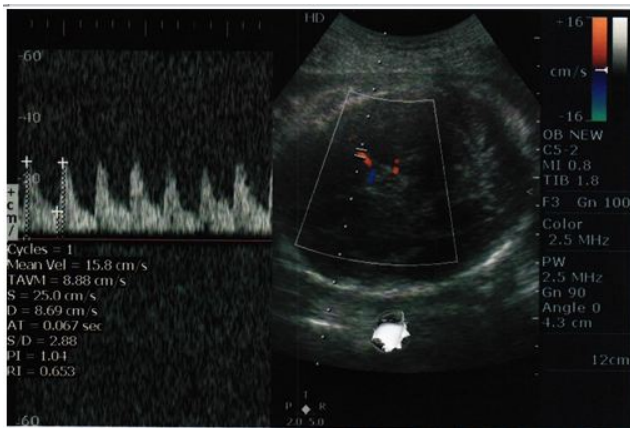


Figure 13: Color and pulse Doppler imaging of fetal middle cerebral artery showing cerebral redistribution with reduced RI and PI values.

DISCUSSION

This is a prospective study done in the department of Obstetrics and Gynaecology, Sree Balaji Medical College and Hospital, Chromepet, Chennai. Study duration is for two years, from August 2010 to September 2012. This study is done in a population of 100 pregnant women with gestational hypertension.

In the present study of 100 hypertensive pregnant women, the mean maternal age is 25.46 yrs, which was comparable to other studies. Duen Holter reported that pregnancy induced hypertension was common in very young teenage women. Guzick and associates in 1987 reported that it was common in older women 30-35 Years of age.

In the present study, 59% were primigravidae and 41% were multigravida. This correlated with the study of Chesley et al. where they found higher incidence of PIH in primigravidae. Whereas in the study conducted by Chin-Ming Liu, the percentage of multigravida is more than primigravidae.

While in Ching Ming Liu's study, 37.67% (249/661) of patients had gestational hypertension, 28% had mild preeclampsia and 55.07% had severe preeclampsia.

In our study group, it was found that anaemia was seen in 18%, Oligohydramnios was observed in 28%. None of the women developed HELLP syndrome, while in Ching-Ming Liu's study, 5.14% (34/661) developed HELLP syndrome [47-55].

CONCLUSION

Abnormal uterine and umbilical artery doppler flow is associated with severe form of hypertension and higher incidence of IUGR. Abnormal PI of MCA/umbilical artery ratio is also associated with IUGR. RI in MCA is less sensitive than RI in umbilical artery. Maternal complications encountered were abruption placentae, eclampsia and most of the cases needed induction of labour and majority of cases went in for operative delivery. Neonatal complications included birth asphyxia,

low birth weight, IUGR, respiratory distress, stained liquor and sepsis which require NICU admissions. Because the changes in the uterine and umbilical circulation strongly correlate with the perinatal outcome, doppler velocimetry is a primary tool for fetomaternal surveillance in hypertensive pregnancy. It is safe, non-invasive technique, easy to perform, easy to interpret, and hence most valuable tool in the management of high risk pregnancy.

FUNDING

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ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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