



The Role of Ultrasound in the Assessment of Fetal Growth and Placental Maturation in Pregnancy Induced Hypertension

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Abstract

Aim: This study was undertaken to evaluate the role of grey scale and Doppler ultrasound in the assessment of fetal growth and placental maturation in pregnancy induced hypertension (PIH).

Methods: Forty pregnant female diagnosed as pregnancy induced hypertension were included. History taking, general and obstetric examination as well as laboratory investigation were done. The periodic follow up was included grey scale ultrasound (fetal biometry, placenta grade and liquor assessment) and Doppler ultrasound (umbilical artery, middle cerebral artery and fetal aorta blood flow). The perinatal outcome results included intrauterine growth retardation (IUGR), prematurity, intrauterine fetal death (IUFD) and early neonatal death were documented and correlated with the ultrasound findings.

Results: There was increased incidence of Grade III placenta in pregnant females with PIH as there were 40 % (n=16) had grade II placenta while 60 % (n=24) had grade III placenta. There was an association between grade III placenta and intrauterine growth retardation. All patients presented with IUGR (n=9) showed abnormal Doppler waveforms. Eight of them had abnormal MCA/UA ratio and only one expressed normal ratio. Increased number of vessels affection was associated with adverse pregnancy outcome as IUGR, prematurity, IUFD and early neonatal death. Umbilical artery Doppler with absent or reversed diastolic flow was ominous signs as both findings were associated with IUFD and neonatal death.

Conclusion: Fetal ultrasound has a valuable role in predicting adverse perinatal outcome associated with PIH. It has important role in assessment of placental maturation and its effect on fetal growth and placental dysfunction. Doppler imaging can significantly evaluate complication associated with PIH by providing valuable information about the hemodynamic state of the fetus.

Keywords: PIH, grey scale ultrasound, Doppler ultrasound, Umbilical artery, Middle cerebral artery, Cerebroplacental ratio, IUGR.

Introduction

Pregnancy induced hypertension (PIH) is the most common medical complication during pregnancy. It is the leading cause of maternal and fetal morbidity and mortality. The most common complication of PIH is intra uterine growth retardation (IUGR).⁽¹⁾

The Japan Society for the Study of Hypertension in Pregnancy (JSSHP) was classified PIH as gestational hypertension (GH), preeclampsia (PE), superimposed preeclampsia (S-PE) or eclampsia (E).⁽²⁾

Fetal growth is heavily modulated by placental function. Early placental problems can occur

because incomplete trophoblast invasion results in failure of remodeling of the myometrial arteries and reduced uteroplacental blood. So it is not surprising; consequently, that intrauterine growth retardation is frequently associated with PIH.^(3,4)

Ultrasound biometry is the gold standard for assessment of fetal size. Fetal weight less than 10th percentile for gestational age is mostly used to diagnose IUGR. The presence of oligohydramnios without ruptured membranes, presence of advanced placental grade and abnormal fetal blood flow can also be used for improving the accuracy of diagnosis.⁽⁵⁾

Blood flow studies were used to assess fetal well being in hypertensive pregnancies. The sensitivity of the Doppler studies can be significantly increased by studying multiple vessels.⁽⁶⁾

Cerebro-placental ratio incorporates data not only on placental status but also on fetal response. The reduction in placental perfusion can be associated with an increase in flow towards the brain. This phenomenon is called the brain sparing effect and it is supposed to compensate for fetal hypoxia and is associated most of the time with fetal growth retardation.⁽⁷⁾

Patients and Methods

Forty pregnant women with present history of pregnancy induced hypertension were referred to the radiology department of Alexandria University to do fetal ultrasound assessment were recruited in this study. Only pregnant women beyond 20 weeks of gestation with systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg with or without proteinuria were included in the study. Each patient was subjected to: Complete history taking, clinical and laboratory examination. Grey scale ultrasound investigating fetal biometry, placenta grade and liquor assessment was done. Also Doppler ultrasound including umbilical artery, middle cerebral artery and fetal aorta blood flow was performed. All sonographic examinations were done by GE LOGIQ P 5 ultrasound machine using a curved

array multi-frequency transducer 3.5 – 5.5 MHz. The medical ethics was considered.

Ultrasound assessment of fetal growth was done by measuring BPD (Biparietal diameter), FL (Femur length) and AC (Abdominal circumference). Average gestational age and effective fetal weight was then calculated. Placental maturation was graded according to the Grannum classification.⁽⁸⁾ Color Doppler was used to assess the various Doppler indices: Pulsatility index (PI), Resistive index (RI) and Systolic diastolic ratio (S/D ratio) in umbilical and middle cerebral arteries and fetal aorta as well as MCA/UA ratio compared to the standard normograms. Incidence of subjects having IUGR, development of oligohydramnios, advanced placental grade and abnormal Doppler indices were calculated. The perinatal outcome results (prematurity, IUFD and early neonatal death) were documented and correlated with the ultrasound findings. Periodic follow up was performed. The results of the first examination and last follow up were documented. The last follow up was used for analysis of perinatal outcome.

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. Comparison between different groups regarding categorical variables was tested using Chi-square test.

Results

The ages of patients in the current study ranged from 18 to 38 years (mean \pm S.D 27.83 \pm 5.62). The majority belonged to the age group of 20-30 years (52.5 %). Twenty one cases (52.5%) were of late onset PIH and 19 cases (47.5%) were of early onset PIH (<34 weeks of gestational age). Classification of PIH in this study was based on the classification presented by the Japan Society for the Study of Hypertension in Pregnancy (JSSHP) 2013.⁽²⁾ Fourteen patients (35%) had gestational hypertension, two patients (5%) had preeclampsia superimposed on chronic

hypertension, two patients (5 %) had eclampsia and 22 patients (55%) had preeclampsia.

There was increased incidence of adverse perinatal outcome as intrauterine growth retardation, prematurity, intrauterine fetal death and early neonatal death in early onset of PIH. Ten out of 13 cases that had premature fetus were of early onset PIH. IUFD was presented by two patients; all of them were of early onset PIH. Early neonatal death was presented by 3 patients; two of them of early onset while only one case of late onset PIH. Nine cases had IUGR all of them were of the early onset PIH.

Number of cases with IUGR was increased from 7 at the initial presentation to 9 at the last follow up. Number of cases with oligohydramnios was increased from 3 at the initial presentation to 9 at the last follow up.

All pregnant patients with gestational hypertension, preeclampsia superimposed on chronic hypertension and mild preeclampsia had normal fetal growth. While in severe preeclampsia 7/11 cases (77.8%) had intrauterine growth retardation. In eclampsia all patients (n=2) had intrauterine growth retardation.

There was increased incidence of Grade III placenta in pregnant females with PIH as 24/40 patients (60%) had grade III placenta. None of the examined patients presented with grade 0 or I placenta. There was association between grade III placenta and intrauterine growth retardation as 8/9 patients (88.9%) with IUGR had grade III placenta. The remaining patient (11.1 %) had grade II placenta. However it did not show statistically significance in this study. There was increased association between grade III placenta and placental insufficiency. Thirteen/16 patients (81.3%) had abnormal Doppler indices were diagnosed as having grade III placenta which was statistically significant ($p=0.025$).

In this study, abnormal Doppler findings were found in 16 patients; UA was abnormal in all 16 patients which was solitary in 3 patients (7.5%).

Six patients (15%) had combined UA and MCA affection. One patient (2.5 %) had combined UA and fetal aorta affection. Six patients (15%) had combined UA, MCA and fetal aorta affection. No patients had solitary MCA or Fetal aorta affection. Umbilical artery Doppler examination showed that 11/40 patients (27.5%) had high resistive flow, 3/40 patients (7.5%) had absent diastolic flow while two/40 patients (5%) had reversed diastolic flow. MCA/UA ratio was normal (>1) in 26/40 patients (65 %) while it was abnormal (<1) in 14/40 patients (35 %).

All patients presented with IUGR (n=9) showed abnormal Doppler waveforms. Two/3 patients who had solitary umbilical artery affection was developed IUGR. Two/ 6 patients who had combined umbilical artery and middle cerebral artery was developed IUGR. Combined umbilical artery and aorta had one case presented with IUGR. Four/6 patients who had Three vessel affection (umbilical artery, middle cerebral artery and aorta) was developed IUGR which was statistically significant ($p<0.001$) (table1). In correlation to the cereproplacental ratio; Eight/9 patients who were developed IUGR showed abnormal MCA/UA ratio and only one expressed normal ratio which was statistically significant in this study ($p=0.002$) (table2).

Table (1): Relation between Number of vessels affected and fetal growth

Number of vessels affected	Growth				c2	MCp
	Normal (n = 31)		IUGR (n = 9)			
	No.	%	No.	%		
No	24	77.4	0	0.0	21.287*	<0.001*
Umbilical	1	3.2	2	22.2		
Umbilical and MCA	4	12.9	2	22.2		
Umbilical and Aorta	0	0.0	1	11.1		
Umbilical and MCA and Aorta	2	6.5	4	44.4		

χ²: value for Chi square

MC: Monte Carlo test

*: Statistically significant at p ≤ 0.05

Table (2) Relation between MCA/UA ratio and Growth abnormalities

Growth	MCA/UA ratio				c2	FEp
	Normal(>1) (n = 26)		Abnormal(≤1) (n = 14)			
	No.	%	No.	%		
Normal	25	96.2	6	42.8	10.852*	0.002*
IUGR	1	3.8	8	57.2		

χ²: value for Chi square

FE: Fisher Exact test

*: Statistically significant at p ≤ 0.05

Increased number of vessel affection showed increase incidence of adverse perinatal outcome including prematurity, IUFD and neonatal death. Two/3 patients having solitary umbilical artery affection were born preterm. Three/6 patients having combined umbilical artery and middle cerebral artery were born preterm. One case had combined umbilical artery and aorta affection had born preterm fetus. Patients having Combined umbilical and middle cerebral artery and aorta affection was diagnosed in 6 patients; 2/6 patients had IUFD. Four/6 were born preterm, three of them developed early neonatal death which was statistically significant in this study (p<0.001) (table3).

Table (3): Relation between Number of vessels affected and perinatal outcome

	Pregnancy outcome								c ²	MC p
	Preterm (n = 13)		Full term (n = 25)		IUFD (n = 2)		Neonatal death(n =3)			
	No.	%	No.	%	No.	%	No.	%		
Number of vessels affected										
No	3	23.1	21	84.0	0	0.0	0	0.0	24.626*	<0.001*
Umbilical	2	15.4	1	4.0	0	0.0	0	0.0		
Umbilical and MCA	3	23.1	3	12.0	0	0.0	0	0.0		
Umbilical and Aorta	1	7.7	0	0.0	0	0.0	0	0.0		
Umbilical and MCA and Aorta	4	30.8	0	0.0	2	100.0	3	100.0		

□²: value for Chi square

MC: Monte Carlo test

*: Statistically significant at p ≤ 0.05

Abnormal MCA/UA ratio was diagnosed in 14 patients. Nine/14 patients had preterm fetus, three of them developed early neonatal death. Other two/14 patients had IUFD which was statistically significant in this study (p<0.001) (table4).

Table (4):Relation between MCA/UA ratio and perinatal outcome

	Pregnancy outcome								c ²	MC p
	Preterm (n = 13)		Full term (n = 25)		IUFD (n = 2)		Neonatal death(n =3)			
	No.	%	No.	%	No.	%	No.	%		
MCA/UA ratio										
Normal (>1)	4	30.8	22	88	0	0.0	0	0.0	13.940*	<0.001*
Abnormal (≤1)	9	69.2	3	12	2	100.0	3	100.0		

□²: value for Chi square

MC: Monte Carlo test

*: Statistically significant at p ≤ 0.05

In umbilical artery Doppler with absent diastolic flow; all cases (n=3) had adverse outcome. Two of them had preterm fetus, one of them had early neonatal death. The remaining one had intrauterine fetal death. In umbilical artery Doppler with reverse diastolic flow; all cases

(n=2) had adverse outcome as there were one case had preterm fetus which had early neonatal death, while one case had intrauterine fetal death which was statistically significant (p<0.001) .

Illustrative cases:

Patient (1): Patient diagnosed as eclampsia. Ultrasound showed IUGR, oligohydraminos, placenta grade III and abnormal Doppler indices in the three examined vessels. Pregnancy was

terminated by CS due to fetal distress at 34 weeks; the baby developed respiratory distress, so admitted to NICU and ended by early neonatal death due to respiratory failure.

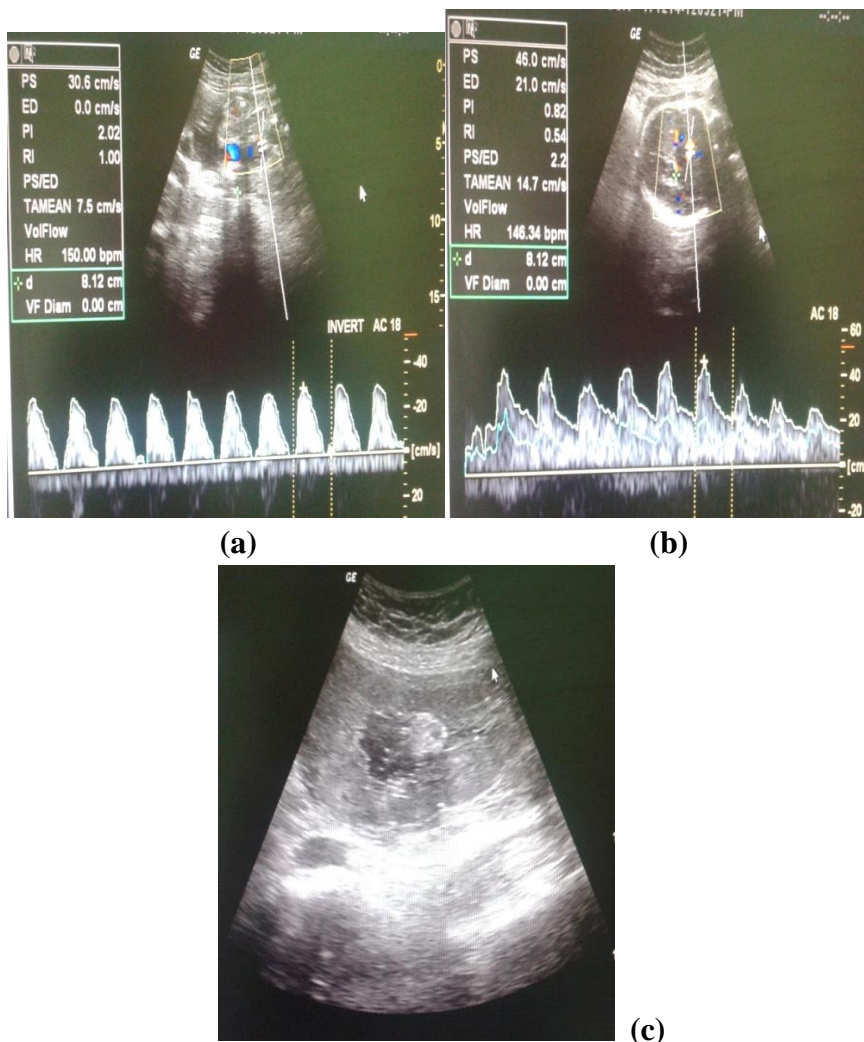


Figure 1: (a) Abnormal umbilical artery wave form with absent diastolic flow. (b) Abnormal low resistive MCA waveform (brain sparing effect). (c) Placenta grade III.

Patient (2): Patient diagnosed as late onset preeclampsia. The initial ultrasound examination done at 35 weeks showed IUGR, borderline liquor volume, placenta grade II and abnormal high restive umbilical artery Doppler indices (RI=0.72), however the middle cerebral artery Doppler and aorta Doppler were of normal

indices. Patient did follow up after one week. In the last follow up; oligohydraminos was developed and the high resistance was seen at the umbilical artery was increased (RI = 0.81). The middle cerebral artery and aorta Doppler were of normal indices. Pregnancy termination by CS at 36 weeks with low birth weight = 1.75 kg.

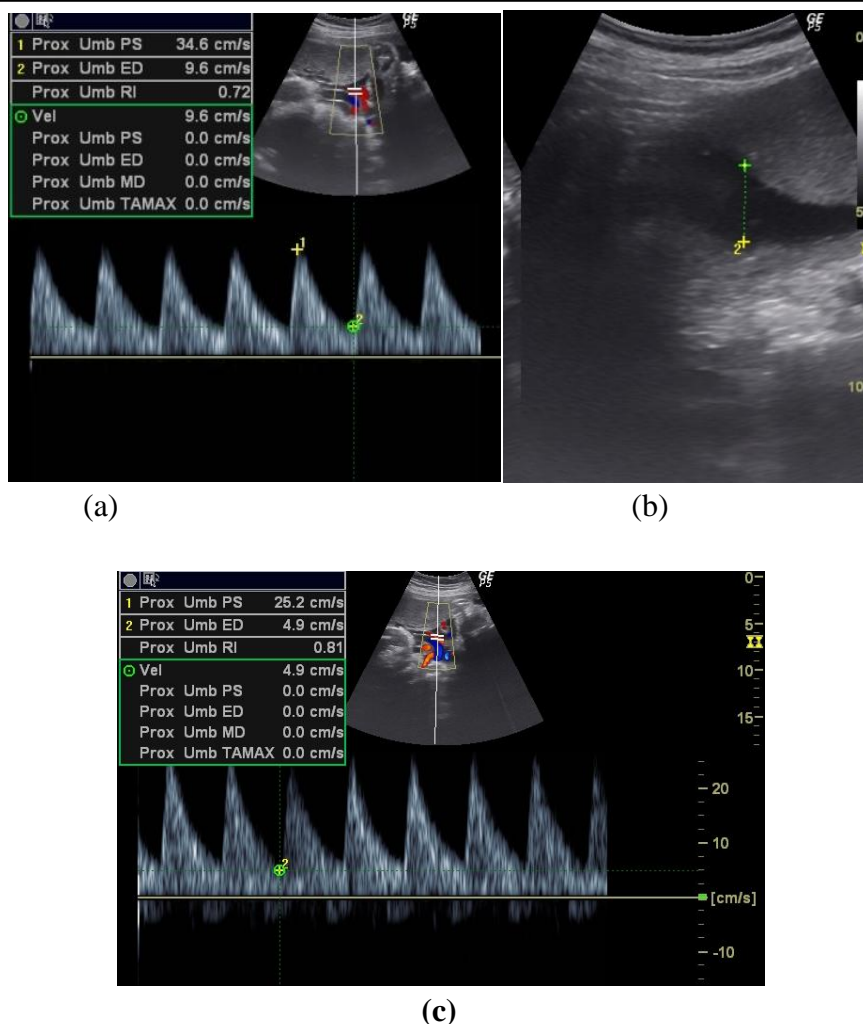


Figure 2: (a) Showed abnormal high resistive umbilical artery Doppler indices (RI = 0.72) in the initial ultrasound examination. (b) Oligohydramnios (AFI=2.1) (c) Showed abnormal high resistive umbilical artery Doppler indices (RI = 0.81) in the last follow up.

Discussion

Satisfactory development of utero-placental and fetoplacental circulation is necessary for a normal pregnancy outcome. Alteration in its development can be associated with hypertension during pregnancy, which can lead to impaired circulation causing prematurity, subnormal growth (IUGR) or fetal death.

This study was undertaken to evaluate the role of grey scale and Doppler ultrasound in the assessment of fetal growth and placental maturation in pregnancy induced hypertension.

The ages of patients in the current study ranged from 18 to 38 years (mean±S.D 27.83 ± 5.62). The majority belonged to the age group of 20-30 years (52.5%). Twenty one cases (52.5%) were of late onset and 19 cases (47.5%) were of early

onset (<34 weeks of gestational age). There was increased incidence of adverse perinatal outcome as intrauterine growth retardation, prematurity, intrauterine fetal death and early neonatal death in early onset PIH. Marshall⁽⁹⁾ reported that early onset preeclampsia (onset <34 weeks' gestation) was associated with greater morbidity than when the disorder presents at term.

In the current study, increase severity of the disease was associated with IUGR. All cases presented with IUGR (n=9) occurred in severe preeclampsia and eclampsia groups. Rasmussen⁽¹⁰⁾ reported that fetal growth restriction is more strongly associated with severe rather than milder pregnancy-induced hypertension.

In the present study, Number of cases with IUGR was increased from 7 at the initial presentation to

9 at the last follow up based on discrepancies between actual and expected biometric measurements for a given gestational age. MAYER⁽³⁾ reported that abnormal fetal growth is typically an ultrasound diagnosis based on discrepancies between actual and expected biometric measurements for a given gestational age.

In the current study, US biometry was used for the assessment of fetal growth. Fetal weight less than 10th percentile for gestational age was mostly used to diagnosis IUGR (n=9). The presence of oligohydramnios without ruptured membranes, presence of advanced placental grade and abnormal fetal blood flow was also used for improving the accuracy of diagnosis. Lausman⁽⁵⁾ used liquor assessment and feto-maternal Doppler study to improve the accuracy of diagnosis. Benson⁽¹¹⁾ reported that detection of IUGR with only weight estimation has some limitations. Therefore additional sonographic criteria presence of oligohydramnios without ruptured membranes and presence of advanced placental grade are also used for improving the accuracy of diagnosis.

In the current study, There was increased incidence of grade III placenta in pregnant females with PIH as there were 40 % (n=16) had grade II placenta while 60 % (n=24) had grade III placenta. Deopa⁽¹²⁾ observed that pregnancy hypertensive cases showed acceleration in the maturity of the placenta. Meckanna⁽¹³⁾ noted that ultrasound detection of grade III placenta helps to predict subsequent development of protenuric PIH.

There was an association between grade III placenta and intrauterine growth retardation as there were 9 patients had IUGR; eight of them had grade III placenta while the remaining one patient had grade II placenta. This agrees with Deopa⁽¹²⁾ who concluded that IUGR cases showed acceleration in the maturity of the placenta.

There was increased association between grade III placenta and placental insufficiency as in group grade III placenta there were 13/16 cases (81.3%) had abnormal Doppler indices. Chen⁽¹⁴⁾

concluded that in high-risk pregnant women, the presence of preterm placental calcification was a predictor of poor uteroplacental flow and adverse pregnancy outcome, requiring closer surveillance for maternal and fetal well-being. Joseph⁽¹⁵⁾ also detected association between abnormal Doppler findings and placenta grade III.

In this study, number of cases with oligohydramnios had increased from 3 at the initial presentation to 9 at the last follow up. Joseph⁽¹⁵⁾ and Nwosu⁽¹⁶⁾ reported that there is association between hypertensive pregnancy and oligohydramnios. He attributed the phenomenon to the fact that uteroplacental insufficiency leads to failure of fetus to achieve its genetic growth potential results due to inability of a defective placenta to meet fetal need. Subsequently, impaired gaseous exchange and nutrient availability leads to fetal asymmetrical growth restriction with relative sparing of the brain. There is impaired urine production and oligohydramnios in fetus due to vasoconstriction in fetal kidney.

This study showed that all patients presented with IUGR (n=9) showed abnormal Doppler waveforms. Considering the number of vessel affection which include two cases with one vessel (umbilical artery affection), two cases with two vessel affection (umbilical and middle cerebral arteries), two case with two vessel affection (umbilical artery and aorta) and four cases with three vessels affection (umbilical and middle cerebral arteries and aorta), all of them presented with IUGR.

Similarly this study show increase incidence of prematurity, IUFD and neonatal death with increase number of affected vessels in Doppler study as; _____ Preterm delivery occurred in 15.4 % of cases having one vessel affection, 30.8 % of cases had two vessel affection and 30.8 % of cases with three vessel affection. In addition to that two cases had IUFD and three other cases had early neonatal death among the group of patients expressing three vessel affection.

Lakhkar⁽⁶⁾ concluded that Doppler studies of multiple vessels in the fetoplacental circulation

can help in the monitoring of compromised fetus and can help us predicting neonatal morbidity as there is association between abnormal Doppler indices and adverse pregnancy outcome including IUGR, prematurity and perinatal death. Hoffman⁽¹⁷⁾ reported that Sequential studies of IUGR Doppler waveforms from different vascular areas can be used to assess the overall wellbeing of the fetus at risk. Khalid M⁽¹⁾ had detected that abnormal indices show strong correlation with adverse fetal outcome and fetal growth retardation.

In umbilical artery Doppler with absent or reverse diastolic flow; all cases had adverse outcome in the current study. So absent or reversed diastolic flow of the umbilical artery Doppler is ominous signs and associated with adverse pregnancy outcome. Similar conclusion had been reported by Khalid⁽¹⁾ and Lakhkar⁽⁶⁾ that absent and reverse diastolic flow of the umbilical artery Doppler are ominous signs and associated with adverse pregnancy outcome. Yoon⁽¹⁸⁾ demonstrated that absent umbilical artery wave form is a strong and important predictor of adverse perinatal outcome. Özgür⁽¹⁹⁾ noted that In the presence of absent or reverse flow in UA fetal death , neonatal complication rates and need for neonatal intensive care unit (NICU) were higher.

This study showed association between abnormal MCA/UA ratio and the incidence of IUGR, prematurity, IUFD and neonatal death. Eight/9 patients who developed IUGR showed abnormal MCA/UA ratio. Nine/14 patients who showed abnormal MCA/UA ratio had preterm fetus, three of them developed early neonatal death. Other two/14 patients had IUFD. This findings matched the reports of Shahinaj⁽⁷⁾ , Deshmukh⁽²⁰⁾ and Smitha⁽²¹⁾ who considered MCA/UA ratio valuable indices for predicting the perinatal outcome in hypertensive pregnancies.

Conclusion

Fetal ultrasound has a valuable role in predicting adverse perinatal outcome associated with PIH. It has important role in assessment of placental

maturation and its effect on fetal growth and placental dysfunction. Doppler imaging can significantly evaluate complications associated with PIH by providing valuable information about the hemodynamic state of the fetus.

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