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Colour Doppler study of Fetomaternal and uteroplacental circulation in pregnancy induced hypertension and/or oligohydramnios

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Abstract
Purpose: To study the fetoplacental and uteroplacental circulation by evaluating uterine artery, umbilical artery and fetal MCA using color Doppler in hypertensive disorders of pregnancy and oligohydramnios in second and third trimester with comparing different parameters.
Methodology: Total 62 antenatal patients in their second or third trimester, who were clinically diagnosed as having pregnancy-induced hypertension or oligohydramnios by department of obstetrics had been recruited. Color Doppler study of umbilical artery, uterine artery and fetal MCA was performed with measurement of umbilical artery PI and SV/DV ratio, MCA PI and SV/DV ratio, uterine artery RI and SV/DV ratio and CPR.At last, color Doppler prediction was correlated with fetal outcome.
Results: Out of 62 patients, 27 had PIH, 14 had associated oligohydramnios with PIH and 21 had oligohydramnios. 56% patients with PIH and 47% patients with oligohydramnios had adverse fetal outcome. The percentages of abnormal parameters of uterine artery, umbilical artery and MCA in PIH patients were 61%, 46% and 51% respectively. The sensitivity and specificity for detecting fetal distress was 70% and 81%, 70% and 87% and 67% and 86% for uterine artery, umbilical artery and fetal MCA respectively. CPR was 100% sensitive and 92.3% specific in detecting severe fetal distress.
Conclusion: Chances of fetal compromise inutero are high in PIH patients, also significant number of oligohydramnios patients show adverse fetal outcome. Color Doppler study of fetoplacental and uteroplacental circulation proved a useful and noninvasive technique in determining hypoxic fetus and planning timely management of delivery before severe hypoxic injury to fetus occurs. Uterine artery and umbilical artery are more sensitive followed by MCA in diagnosing fetal distress.

Keywords: Pregnancy induced hypertension, oligohydraminos, feto-maternal circulation, colour Doppler

Introduction
Diagnostic ultrasound in the 21st century has provided a newer horizon in the imaging modality. Doppler is considered to be the best tool in investigating and assessing accurate changes in fetomaternal and uteroplacental circulation and to predict perinatal outcome to take decision for appropriate intervention.
Hypertensive disorders of pregnancy are one of the most common complications that affect the mother. It is one of the leading causes of maternal and fetal mortality and morbidity. Oligohydraminos is the condition of having little amniotic fluid during pregnancy, which can occur due to various causes, or it may be an effect of PIH itself. In either way, it can lead to IUGR, which eventually increases fetal morbidity and mortality.
The traditional methods of fetal surveillance like non-stress test, fetal heart monitoring, fetal biophysical profile are no more ideal tests because of their inability to detect early stages of fetal distress. Early recognition of fetal compromise by Doppler Ultrasound may help in reducing the incidence of perinatal mortality and morbidity.
The purpose of study is to evaluate the role of color Doppler in predicting fetal outcome in patients with PIH or oligohydraminos.

Safety of diagnostic ultrasound in fetal scanning
Ultrasound causes thermal and mechanical effects in tissue, which are increased as the output power is increased [1].

In response to these increases, recommendations for the safe use of ultrasound have been issued by several bodies.

Current regulations

Regulations governing the output of diagnostic ultrasound have been set by the USA's Food and Drug Administration (FDA).

The new regulations allow an eight-fold increase in ultrasound intensity to be used in fetal examinations. The output display is based on two indices, the mechanical index (MI) and the thermal index (TI):

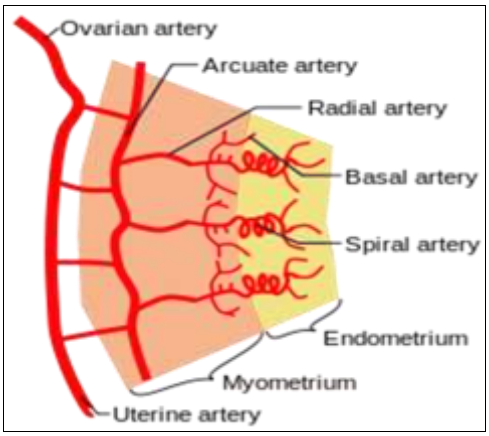
1) The FDA regulations allow a mechanical index of up to 1.9 to be used for all applications except ophthalmic (maximum 0.23).
2) Thermal index: should be less than 1.

The mechanical index and thermal index must be displayed if the ultrasound system is capable of exceeding an index of one.

Uteroplacental circulation

Anatomy

The blood supply to the uterus comes mainly from the uterine arteries, with a small contribution from the ovarian arteries. Maternal blood enters the placenta through the basal plate endometrial arteries (spiral arteries), perfuses intervillous spaces, and flows around the villi where exchange of oxygen and nutrients occurs with fetal blood [2].



(Wikimedia.org/wiki/File: Uterine arterial vasculature.svg)

Fig 1: Uterine artery vasculature

Uterine artery color doppler

Impedance to flow in the uterine arteries decreases with gestation.

Normal Pregnancy - Development of the uterine artery

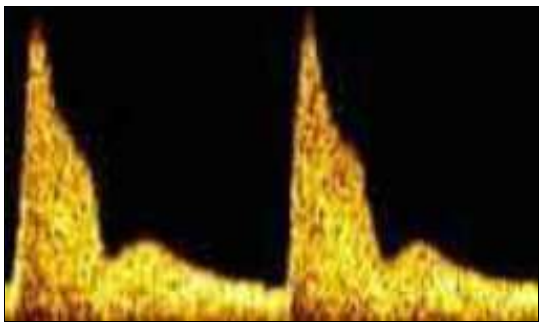


Fig 2: Normal impedance to flow in the uterine arteries in early second trimester

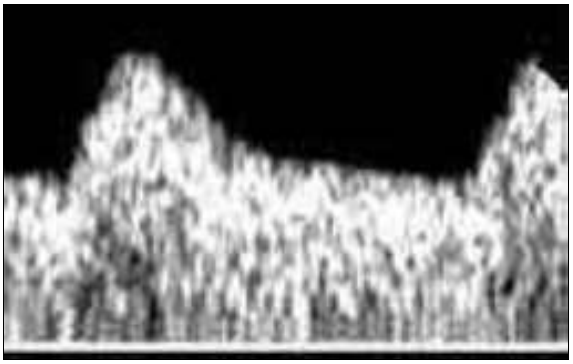
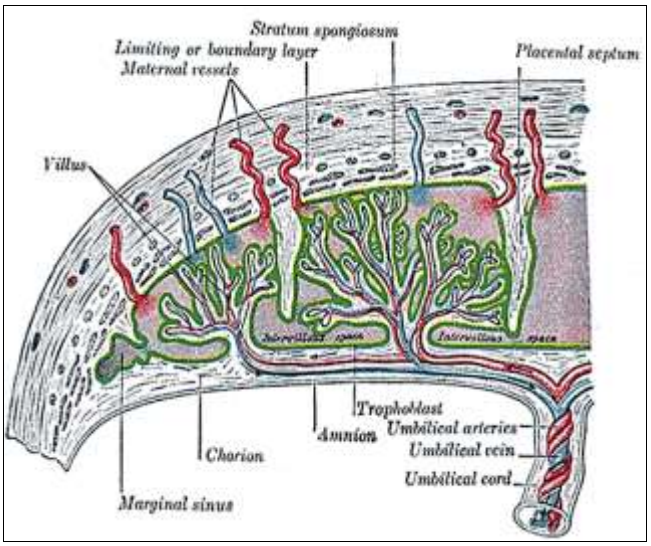


Fig 3: Normal impedance to flow in the uterine arteries in late 2nd and 3rdtrimester (Doppler in Obstetrics by The Fetal Medicine Foundation, chapter 3)

Umbilical artery



(http://www.slideshare.net/Lucidante1/implantation-and-placenta-formation)

Fig 4: Umbilical artery anatomy

Umbilical artery flow

Flow velocity waveforms from the umbilical cord have a characteristic saw-tooth appearance of arterial flow in one direction and continuous umbilical venous blood flow in the other. Before 12 weeks of gestation, flow velocity waveforms show absence of end diastolic velocities. End diastolic velocities in the umbilical vessels appear by about 16 weeks of gestation. Further decrease of resistance occurs as pregnancy advances resulting in low RI and PI value.

Normal Pregnancy - Development of the umbilical artery

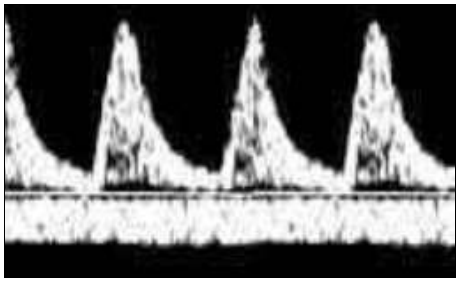


Fig 5: Normal impedance to flow in the umbilical arteries and umbilical vein in early second trimester with end diastolic flow

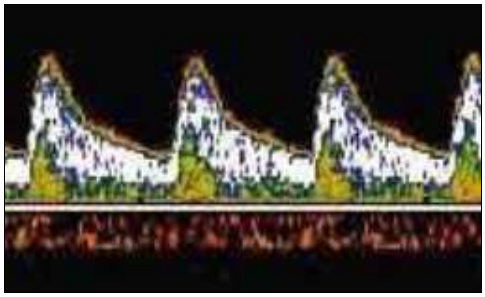


Fig 6: Normal impedance to flow in the umbilical arteries and umbilical vein in late 2nd and 3rd trimester with end diastolic flow (Doppler in Obstetrics by The Fetal Medicine Foundation, chapter 3)

Middle cerebral artery

Fetal middle cerebral arterial Doppler assessment is an important part of assessing fetal cardiovascular distress, fetal anaemia or fetal hypoxia.

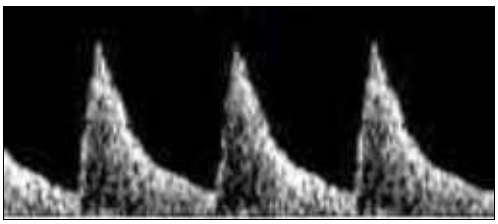


Fig 7: Normal flow of the middle cerebral artery in second and third trimester (Doppler in Obstetrics by The Fetal Medicine Foundation, chapter 3)

2.1 Aims And Objectives

Aim

To evaluate and study the fetoplacental and uteroplacental circulation by color Doppler in hypertensive disorders of pregnancy and oligohydramnios in second and third trimester so that we may predict various complications that may arise because of the above-mentioned conditions.

Objectives

- To determine usefulness of uterine artery spectral Doppler assessment in PIH
- To determine the most effective parameter in predicting PIH
- To check sensitivity and specificity of various vessels in assessment of fetal compromise.

3. Materials and Methods

Data for study was collected from second and third trimester patients of clinically suspected PIH and / or oligohydraminos, referred to the department of Radio diagnosis.

Inclusion criteria

1. Hypertensive disorders of pregnancy
- Gestational hypertension
- Pre eclampsia
- Eclampsia
2. Oligohydramnios: AFI < 8 cm

Exclusion criteria

1. Chronic renal diseases
2. Severe malnutrition
3. Chronic hypertension
4. Hypertension due to other causes like vascular, endocrinal, and neurogenic
5. Multiple pregnancies
6. First trimester pregnancy

Technique

Ultrasound scan and color Doppler study of fetus was done using my lab 20 plus or my lab 40 (ESAOTE) with 3.5 MHz curvilinear probe in supine position with hands below head. First grey scale evaluation of fetus was done and necessary fetal parameters were taken, then color Doppler evaluation of fetal umbilical artery, MCA and uterine artery was done.

Amniotic fluid index measurement

Uterus is divided into four imaginary quadrants with linea nigra and umbilicus acting as the vertical and the horizontal axis respectively. The deepest pocket devoid of umbilical cord and fetal parts is measured in the vertical dimension measurement of the four pockets is in centimeters, sum of all the four quadrant measurements is AFI.

Values:

AFI = 8-18 cm is considered normal;

AFI of <8 implies oligohydramnios

The following indices were taken into consideration for assessment

1. Uterine artery SV/DV ratio value
2. Uterine artery RI value
3. Umbilical artery SV/DV ratio value
4. Umbilical artery PI value
5. MCA PI
6. MCA SV/DV ratio value
7. Cerebroplacental ratio (CPR): The CPR has been constructed using various Doppler indices (systolic/diastolic ratio, RI, PI) to predict adverse outcomes. In this study, we had measured CPR based on PI value.

Umbilical artery: The transducer is placed on the mother's abdomen overlying the fetus and is systematically manipulated to obtain the characteristic waveforms from the umbilical artery. A free-floating portion of the cord is identified and the Doppler sample volume is placed over an artery.

Uterine Artery: For uterine arteries, flow velocity waveforms are obtained from the lateral lower quadrants of the uterus, angling the transducer on either side of the uterus towards the cervix Region lateral to uterus examined external iliac artery and adjacent vein identified. Uterine artery is seen crossing the external iliac artery on its course from the internal iliac artery to the body of the uterus (figure 8).

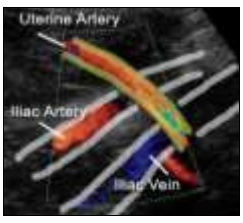


Fig 8: Site of intonation of uterine artery ("crossing over")

Middle cerebral artery: A transverse view of the fetal brain is obtained at the level of the biparietal diameter. The transducer is then moved towards the base of the skull at the level of the lesser wing of the sphenoid bone. Using color flow imaging, the middle cerebral artery can be seen as a major lateral branch of the circle of Willis, running antero-laterally at the borderline between the anterior and the middle cerebral fossae. The pulsed Doppler sample gate is then placed on the middle portion of this vessel to obtain flow velocity waveforms.

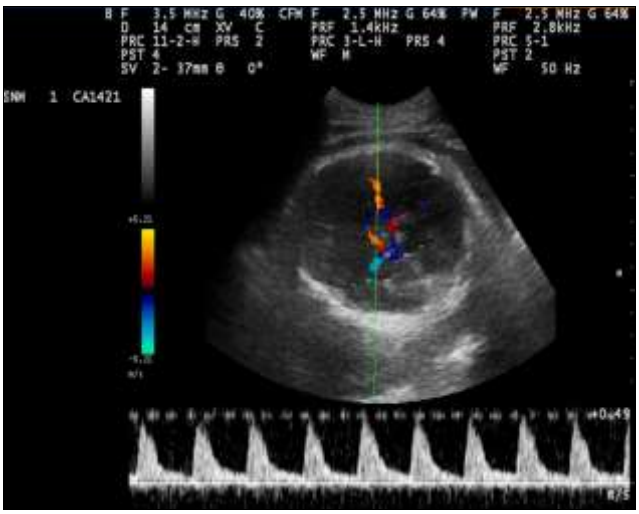


Fig 9: Normal MCA waveform

The abnormal cut off values for fetoplacental insufficiency:

1. Umbilical artery sv/dv ratio > 3[3]
2. Umbilical artery pi more than one sd of mean for appropriate ga [4]
3. MCA pi <5th percentile of appropriate ga
4. MCA sv/dv ratio < 4[3]
5. CPR < 1.08[3]

The abnormal cut off values for uteroplacental insufficiency

1. Uterine artery RI
2. Schulman and colleagues reported 0.63 [5] and Fleischer and co-workers 0.62 [6]. In this study value>0.62 is taken as a cut off value.
3. Uterine artery SV/DV ratio > 2.6 [7]

Fetal outcome criteria

Adverse perinatal outcome was defined as the presence of any of the following:

1. Low birth weight (<2.5 Kg)
2. 5 minute Apgar score of less than <7
3. Admission to NICU and NICU stay> 48 hours
4. Intrauterine death/perinatal death/still birth.

4. Observations and results

Total 62 patients were evaluated with color Doppler. Doppler evaluation of antenatal patients with PIH or oligohydramnios was performed who were referred to ultrasonography department of Radiology.

Table 1: Case distribution

No of patients with pih	27
No of oligohydramnios	21
No of patients having pih with oligohydramnios	14
Total no of patients	62

From above table, we can say that there is association between PIH and Oligohydramnios (22.5%).

Table 2: Uteroplacental insufficiency

	No of patients with Uteroplacental insufficiency	**No of patients with normal Uteroplacental Circulation**
No of pih patients	25	16
No of patients with only oligohydramnios	02	19

According to table 2 data 61% patients of PIH shows uteroplacental insufficiency. Only 10% patients of oligohydramnios had abnormal uterine artery indices.

Table 3: Comparison between presence of uterine artery early diastolic notch and abnormal parameters in uteroplacental insufficiency in PIH patients (fig 10)

Total no of pih patients	**No of pih patients with abnormal parameters without diastolic notch**	**No of pih patients with only early diastolic notch**	**No of pih patients with notch and abnormal parameters**
41	13	0	12

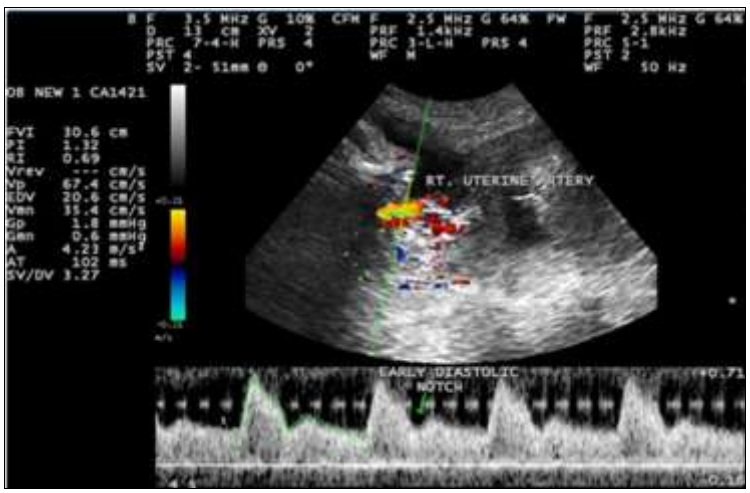


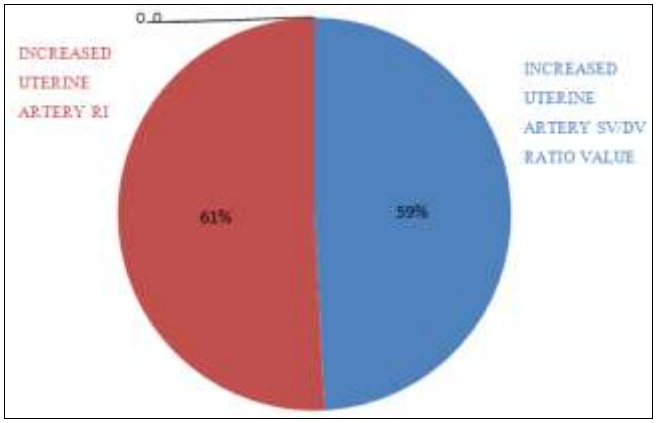
Fig 10: Right uterine artery with diastolic notch and increased indices.

Table 4: Comparison between bilateral and unilateral uterine artery diastolic notch in predicting PIH

No. of pih patients	
Unilateral notch	05
Bilateral notch	08

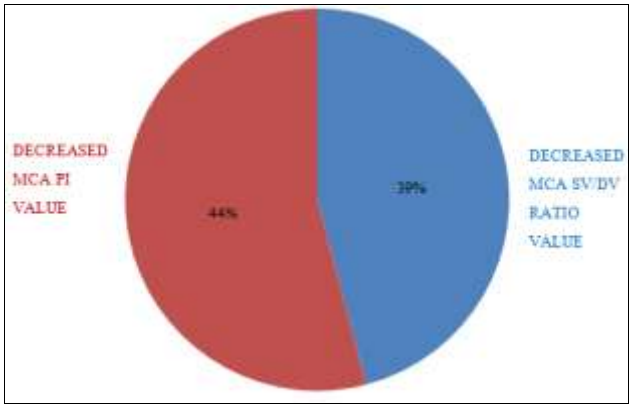
Above table shows that 32% patients of PIH had diastolic notch. Bilateral notch has more sensitivity in predicting PIH than unilateral notch. Out of 08 pregnancies with bilateral diastolic notch, 05 resulted in NICU stay/ APGAR<07, whereas 03 pregnancies with unilateral notch resulted in NICU stay/APGAR<07.

Comparison between uterine artery RI and SV/DV ratio value in predicting PIH



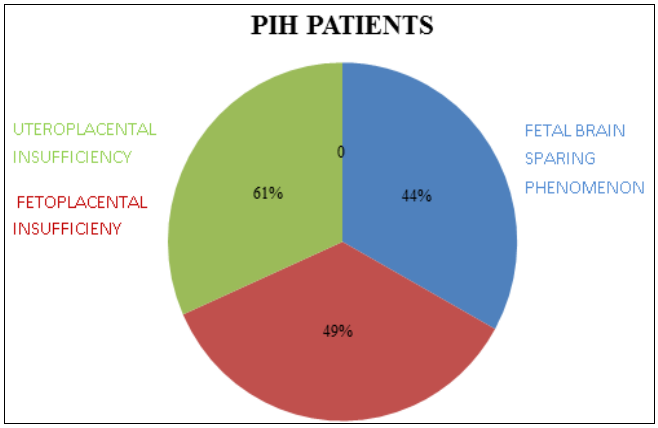
Pie Chart 1: Comparison between increase RI and SV/DV ratio in PIH

The percentage of abnormal MCA Doppler is 44% and 24% in PIH and oligohydramnios respectively.

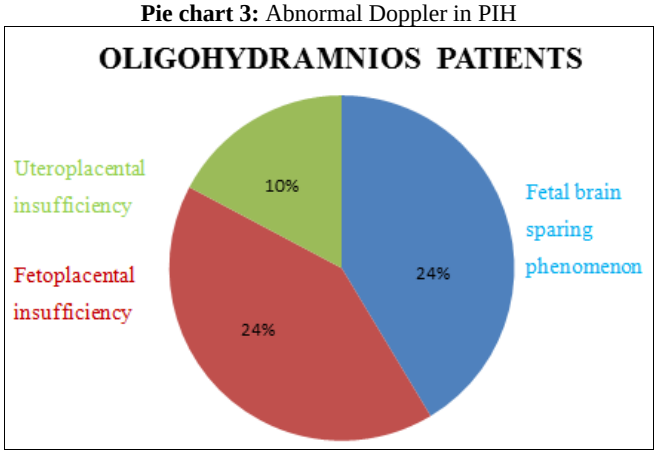


Pie chart 2: Decreased MCA PI and SV/DV ratio in PIH

In this study, percentage of fetoplacental insufficiency in PIH group is 49% and in oligohydramnios is 24%.



Pie chart 3: Abnormal Doppler in PIH



Pie chart 4: Abnormal Doppler in oligohydramnios

Table 5: Fetal outcome

	LBW	NICU STAY > 48 HOURS	05 MIN APGAR SCORE < 7	Stillbirth	Normal
PIH	20	18	11	01	18
Oligohydramnios	07	07	02	0	14

From above table it is evident that percentage of adverse fetal outcome is 56% in PIH.

Table 6: Various Doppler indices in predicting adverse fetal outcome

	TP	FN	FP	TN	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Uterine artery RI	21	09	06	26	70	81	78	74
Uterine artery SV/DV ratio	20	10	06	26	67	81	78	72
UA Pi	16	14	01	31	53	97	94	69
Ua SV/DV ratio	21	09	04	28	70	87	84	76
Mca PI	20	10	03	28	67	86	87	74
Mca SV/DV ratio	16	14	02	30	53	94	89	68
CPR	19	11	0	32	63	100	100	75

(TP – True positive, FN- False negative, FP- False positive, TN- True negative)

Table 7: Umbilical artery EDF and adverse fetal outcome

	LBW	NICU STAY>48 hours	05 min APGAR<07	Stillbirth
Decreased EDF	08	09	08	0
Absent EDF	0	01	01	0
Reverse	0	0	0	1
Normal	0	0	0	0

In this study 09 patients show decreased umbilical artery EDF, 01 had absent and 01 had reverse diastolic flow in umbilical artery. Pregnancy with reverse flow resulted in stillbirth (fig 11).

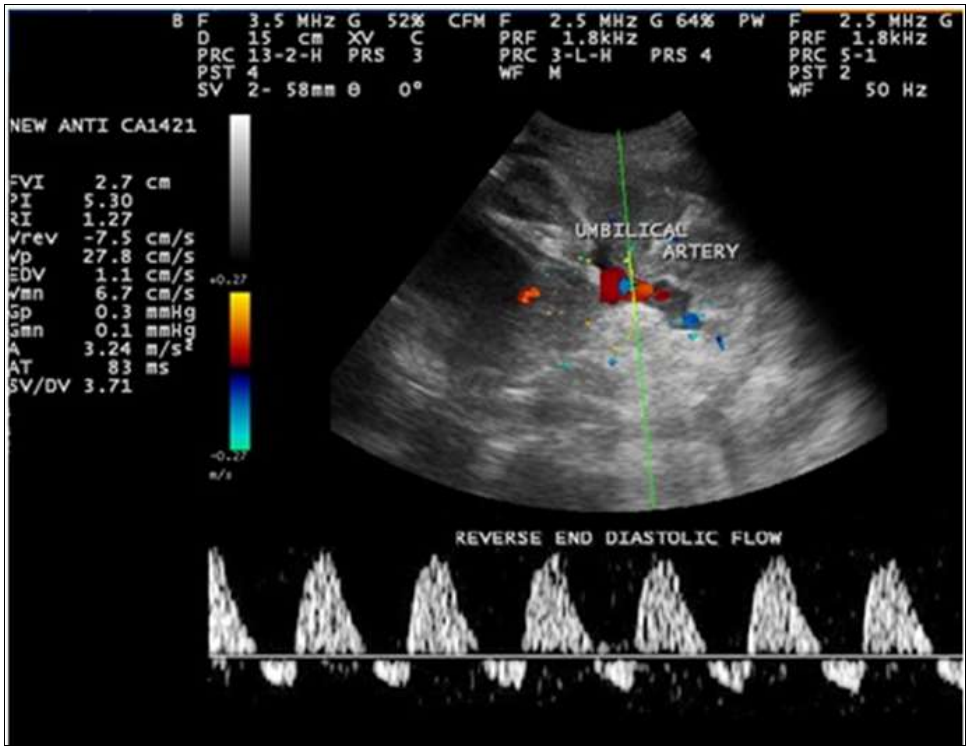


Fig 11: Reversal of EDF in umbilical artery.

Table 8: Association of CPR and abnormal umbilical artery EDF with 05 minute APGAR<07

	CPR		Umbilical Artery	
	<1.08	**>1.08**	**Abnormal**	**Normal**
APGAR<07	14	0	09	05
APGAR>07	04	49	0	44

From above table, CPR has 100% sensitivity and 92.3% specificity in diagnosing severe fetal distress.

Table 9: Association of amniotic fluid with adverse fetal outcome

	Adverse fetal outcome	Normal fetal outcome
Oligohydramnios with or without PIH	14	21
Normal	16	11

Above table shows, that out of 30 patients with adverse fetal outcome 14 had oligohydramnios, which is 47% of adverse fetal outcome.

5. Discussion

In patients with preeclampsia due to inadequate trophoblastic invasion of the maternal spiral arterioles, there is abnormal placentation. This in turn causes increased vascular resistance in uteroplacental circulation and decreased perfusion, resulting in increased incidence of IUGR, fetal hypoxia and perinatal death.

In this study, color Doppler evaluation of uteroplacental and fetoplacental circulation was performed on total 62 antenatal patients, out of which 41 patients had PIH and 19 patients had oligohydramnios. Out of 41 patients of PIH 14 have associated oligohydramnios, which is of 34% of total PIH patients.

PIH is associated with adverse fetal outcome which is in this study is 56%. Furthermore, 47% patients with adverse fetal outcome are associated with oligohydramnios.

Uterine artery

Resistive index: In this study 61% of PIH cases show increased RI value as comparable to study done by Zimmerman P which shows 42% patients with increased RI [8].

SV/DV Ratio: In a prospective study done at Panna Dhai Rajkiya Mahila Chikitsalaya, Udaipur [9] the percentage of increased uterine artery SV/DV ratio was 60%, which is 59% in this study.

Significance of diastolic notch: Persistence of notch after 26 weeks of gestation is an indicator of PIH /IUGR. Disappearance of notch will happen first in the uterine artery, which is directly under the placenta. In a study by Sharma S et.al, the sensitivity of uterine artery diastolic notch was found to be 15.63% [10]. In present study, the sensitivity of diastolicnotch in PIH is 32%. Furthermore presence of diastolic notch in bilateral uterine is more significant in predicting PIH and adverse fetal outcome than unilateral notch.

Umbilical artery

Pulsatility index: In a study done by Smitha K, Sowmya K andMalathi T[11], the percentage of abnormal PI value is 45%, when cut off value for abnormal PI was taken two SD above mean. In current study, with abnormal cut off value one SD above mean 32% patients had abnormal PI.

SV/DV Ratio: Fleischer *et al* show that about 40% of hypertensive pregnancies have increased resistance in the umbilical artery, which is significantly associated with IUGR & perinatal mortality & morbidity [12]. In this study, 49% of PIH patients had increased SV/DV ratio. Out of 20patients with raised umbilical artery indices, 11 patients had decreased end diastolic flow; 01 had absent EDF and 01 had reverse EDF. Pregnancies with decreased/absent EDF

resulted in severe fetal distress, whereas pregnancy with reverse EDF resulted in stillbirth. This suggests that chances of severe fetal compromise is more with decreased or absent EDF and greater with reverse EDF. In current study, the percentage of fetoplacental insufficiency in oligohydramnios group was 24%.

Middle cerebral artery
MCA Pulsatility Index
The cut off value for MCA PI in this study was less than fifth percentile for appropriate GA. In a study done by Smitha K, Sowmya K and Malathi T [11], the percentage of abnormal PI value was 76% in PIH group, which is in this study 44%.

SV/DV Ratio
The cut off value for MCA SV/DV ratio in this study was <4.0 and 41% of patients with PIH had decreased MCA SV/DV ratio. The percentage of patients with PIH with decreased MCA PI is higher than decreased MCA SV/DV ratio value, which indicates that MCA PI is more predictive of fetal hypoxia or IUGR.

Oligohydramnios and adverse fetal outcome
Major malformations were more common in pregnancies with oligohydramnios (25%) and borderline AFI (10%) than in those with normal fluid (2%) [13]. In this study, 47% of patients with oligohydramnios, with or without PIH, show adverse fetal outcome.

Diagnostics value of Doppler findings for adverse fetal outcome

Uterine artery
1) RI

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Bhushan And Shefeek [14]	46	90	75	73
In This Study	70	81	78	74

2) SV/DV Ratio

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Bhushan And Shefeek [14]	69	90	81	82
In this study	67	81	78	72

As compare to study done by Bhushan and Shefeek, current study shows sensitivity of uterine artery RI more than SV/DV ratio in adverse fetal outcome.

Umbilical artery

1) PI

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Bhushan And Shefeek [14]	50	31	75	76
In this study	53	97	94	69

2) SV/DV Ratio

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Bhushan And Shefeek [14]	69	90	81.6	82.8
In this study	70	87	84	76

As compare to study done by Bhushan and Shefeek, current study shows sensitivity of umbilical artery SV/DV more than PI in adverse fetal outcome.

Middle cerebral artery

1) PI

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Laxmi V.A.A. Indira K *et al*. [15]	62.2	78.7	76.7	64.9
In this study	67	86	87	74

2) SV/DV Ratio

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
V.A.A. Laxmi, Indira K *et al*. [15]	83	70.2	75.8	78.5
In this study	53	94	89	68

As compare to study done by Laxmi V.A.A., Indira K*et all*, current study shows sensitivity of MCA PI more than SV/DV ratio in adverse fetal outcome.

Cerebroplacental ratio

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Gramellini D[3]	68	98.4	94.4	88
In this study	63	100	100	75

Diagnostic value of cpr for apgar< 7

	Sensitivity (%)	Specificity (%)
LaxmiA.A.A. Indira K *et al*. [15]	100	72.8
In this study	100	100

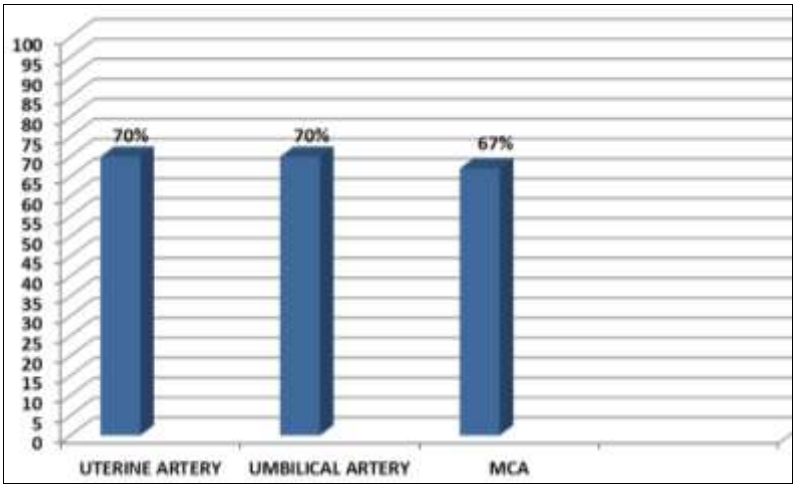


Fig 12: Sensitivity of various vessels in predicting adverse fetal outcome in this study

Timing of delivery

Abnormal Doppler findings of umbilical artery or MCA or both confirm fetal hypoxia and abnormal uterine artery Doppler confirms placental insufficiency with or without fetal hypoxia.

Brain sparing effect is suggestive of ongoing fetal adaptation to hostile intrauterine environment in the early stage of IUGR. Study has shown that this early stage of fetal arterial redistribution does not show fetal metabolic acidemia [16].It is therefore inferred that delivery at this early stage of redistribution has no long-term neurodevelopmental complications. Pregnancy with absent umbilical artery EDF can be managed medically with aggressive monitoring, bed rest and follow up Doppler study. If follow up Doppler study suggest worsening of fetal hypoxia, delivery should be done; otherwise, continuation of delivery until fetal lung maturity can be done. With reverse umbilical artery EDF, strong consideration for delivery should be given except for extreme prematurity. Cesarean section should be given preference in this setting, as labor may cause further fetal hypoxia. In this study, out of 40 patients with abnormal Doppler findings 24 had delivered by LSCS with resultant LBW or NICU stay or low APGAR but none had intrauterine or perinatal death or stillbirth except one with reverse EDF, in whom result was stillbirth.

6. Conclusion

From this study, it is evident that chances of fetal compromise inutero are high in PIH patients. Significant numbers of patients, with adverse fetal outcome, are associated with oligohydramnios. It is concluded from this study that uterine artery RI is more useful in predicting PIH and adverse fetal outcome. In our study, we found MCA PI and umbilical artery SV/DV ratio more significant in adverse fetal outcome as compared to MCA SV/DV ratio and umbilical PI.CPR is 100% sensitive in predicting severe fetal distress. Combined consideration of different parameters of umbilical artery, uterine artery and fetal MCA results in increased sensitivity for fetal distress with decreased in false positive results. This study shows sensitivity of uterine artery and umbilical artery similar (70%) followed by fetal MCA (67%).

7. References

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