Role of Umbilical Artery Doppler in Prediction of Adverse Perinatal outcomes in Hypertensive Disorders of Pregnancy

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Abstract:

Background: Using Umbilical Artery Doppler indices to detect fetoplacental compromise early and to understand the predictive significance of each index in predicting perinatal outcome and therapeutic methods for these patients.

Methods: The present prospective study was conducted at Department of Obstetrics and Gynaecology, Bokaro General Hospital from 1st September 2018 to 31st March 2020 (18 months) on 100 women with hypertensive disorder of pregnancy. Umbilical artery doppler evaluation done in all the patients at (28-32) weeks, (33-36) weeks and (37-40) weeks of gestation and more frequently in those patients having deranged Doppler. Patients divided into two groups women with abnormal Umbilical artery indices and normal indices. Perinatal outcome of both the groups were compared, analyzed statistically using Chi-square test. Multiple pregnancy, chronic hypertension, fetal congenital anomalies, systemic disease and those lost to follow up till delivery were excluded from study.

Results: A total of 100 women with pregnancy induced hypertension were taken into this study after considering inclusion and exclusion criteria. After last Doppler study, patients were divided into two groups, study group and the control group. Out of 100 the study group contain 38 women with abnormal umbilical artery Doppler indices and the control group contain 62 women with abnormal umbilical artery Doppler indices. Hypertension in pregnancy affects women of all ages. In our study the mean maternal age was 27.76 years.

Conclusion: The most accurate way to anticipate unfavorable prenatal outcomes and assist in choosing the right moment for intervention to enhance perinatal outcomes is with umbilical artery PI.

Keywords: Hypertensive disorders, Perinatal adverse outcomes, Sensitivity, Umbilical artery Doppler indices.

Introduction

Though pregnancy is a physiological state it involves risks. Many gestational changes begin soon after fertilization and continue throughout the pregnancy. Equally astounding is that the women are returned almost completely to her pre pregnancy state after delivery and lactation. But some women develop complications during its evolution putting both mother and fetus health at risk. Of which hypertensive disorders represent the most common medical complications of pregnancy affecting between 7% and 15% of all gestations and account for approximately a quarter of all antenatal admissions. [1] According to WHO's systemic review on maternal mortality worldwide,

hypertensive disease remains a leading cause of direct maternal mortality. Together with haemorrhage and infection, hypertension forms the deadly triad that contributes to morbidity and mortality during pregnancy and childbirth. [2] It's a leading cause of maternal and perinatal deaths in developing countries. [3]

Although maternal mortality is much lower in high income countries than in developing countries, the incidence of preeclampsia has risen in US. [4] This might be related to an increased prevalence of predisposing disorders such as chronic hypertension, diabetes and obesity. [5] About 16% of maternal deaths are attributed to hypertensive disorders in developed countries and over half of these hypertension related deaths were preventable.[6] Recent confidential enquiry into maternal deaths in UK found hypertensive disorders to be the second leading direct cause of maternal death. [7]

Hypertensive disorders are responsible for not only maternal deaths but also substantial morbidity for the pregnant women. One third of severe maternal morbidity was a consequence of hypertensive conditions in the United Kingdom. Five percent of women (1 in 20) with severe preeclampsia or eclampsia were admitted to intensive care. [8] long term impact of hypertension in pregnancy in the form of chronic hypertension and increased life time cardiovascular risk is also present.

The American College of Obstetricians and Gynecologists (The College) Task Force on Hypertension in Pregnancy chose to continue using the classification schema first introduced in 1972 by the College and modified in the 1990 and 2000 reports of National High Blood Pressure Education Program Working Group [9] which considers hypertension during pregnancy in four categories:

1. Preeclampsia–eclampsia,
2. Chronic hypertension (of any cause),
3. Chronic hypertension with superimposed preeclampsia; and
4. Gestational hypertension.

Hypertensive disorders also carry a risk for the baby. Hypertension and/or proteinuria is the leading single identifiable risk factor in pregnancy associated with stillbirth. In the most recent UK perinatal mortality report, 1 in 20 (5%) stillbirths in infants without congenital abnormality occurred in women with preeclampsia. Preeclamspia is strongly associated with FGR, low birth weight, spontaneous or iatrogenic preterm delivery, RDS, admission to neonatal intensive care and cerebral palsy. [10]

It causes 10-15% of maternal deaths especially in developing countries [11] and responsible for 18% of fetal and infant mortality as 46% of infants born

for small for gestational age [12]. Perinatal mortality is an important indicator of the quality of obstetric care during pregnancy [13,14]. Perinatal period commences at 28 completed weeks of gestation and ends seven completed days after birth. Preterm birth is the most common cause of perinatal mortality, causing almost 30% of neonatal deaths [15].

Complications of pregnancy induced hypertension which predict perinatal outcome are preterm birth, IUGR babies, placental abruption, fetal hypoxia, nonreassuring fetal status and perinatal death [14]. Predicting these complications may improve the perinatal outcome by providing appropriate antenatal surveillance and therapeutic intervention.

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.

It is here that the role of color doppler comes to detect these early stages of fetal distress by providing a unique, noninvasive and safe method of studying blood flow characteristics in both the fetoplacental and uteroplacental circulations that is being used in clinical evaluation of high risk pregnancies [16].

Doppler ultrasound provides information regarding three aspects

1. Velocity
2. Resistance to blood flow through a particular vessel
3. Volume of blood flow.

Umbilical artery doppler reflects the placental function and indicates the degree of placental insufficiency [17,18] and is the most evaluated test among noninvasive tests of fetal wellbeing.

In clinical studies, vessel with relatively high diastolic flow velocities are believed to reflect low downstream impedance to flow and those with low diastolic velocities reflects high impedance. In this way most commonly used indices are, S/D ratio, PI, RI provides a semi quantitative assessment of impedance in the vessel interrogated.

Altogether, Doppler ultrasound helps one to identify the fetus at risk and time of delivery. The timed diagnosis of fetal compromise is important so that delivery can be affected before fetus suffers irreversible damage and dies in utero. Doppler does correlate well with the fetal compromise giving earlier warning signs of fetal distress than other tests. Present study is an effort to establishing the role of UA Doppler ultrasound in predicting adverse perinatal outcome in hypertensive

disorders of pregnancy and to determine its role in clinical management of such pregnancies.

Aim and Objectives

Aim: To study the role of umbilical artery Doppler velocimetry in predicting the adverse perinatal outcomes in hypertensive disorders of pregnancy.

Objectives:

1. Early detection of fetoplacental compromise in hypertensive disorders of pregnancy with umbilical artery indices i.e. pulsatility index, resistance index and systolic/diastolic ratio.
2. To know the predictive power of each indices of Umbilical Artery (S/D ratio, PI and RI) Doppler in predicting perinatal outcome and interventional strategies.

Material and Methods

This hospital based prospective study done at Department of Obstetrics and Gynaecology, Bokaro General Hospital from 1st September 2018 to 31st March 2020 (18 months). The hospital has a full-fledged Obstetrics & Gynaecological service and about 3000 patients attending OBG OPD every year. All antenatal cases as per the inclusion and exclusion criteria attending the OPD or admitted under OBG department, Bokaro General Hospital, Bokaro.

Study Population: All pregnant women with hypertensive disorders of pregnancy at 28 to 40 weeks as per inclusion and exclusion criteria.

Sample Size: The sample size for the proposed study is approximately 100.

N (total population)= 3196 (nearly)

N (sample size for current study)= 100

Z= statistics for level of confidence (i.e. 1.96 for 95% confidence level)

Confidence level is 95%

P= expected prevalence=7%=0.07

D= precision=5%=0.05

$n=[Z^2P(1-P)]/D^2$

$n=[(1.96)^2 (0.07)(1-0.07)]/(0.05)^2]$

=100.035

=100

This was the required sample size.

Methods

This was a prospective study which was carried out to determine the role of color Doppler in prediction of perinatal outcome in hypertensive disorders of pregnancy.

The cases for the study were selected from patients attending to ANC OPD.

After informed consent women were evaluated with umbilical artery Doppler indices at 28-32 weeks, 33-36 weeks and 37-40 weeks of gestation and more frequently in those patients who are clinically indicated to determine a favorable or a worsening trend in the Doppler indices. Findings of last Doppler examination were taken in to consideration. After last Doppler study, patients were divided in to two groups, study group and the control group. Study group was containing those patients with abnormal UA indices and control group was containing those patients with normal Doppler indices. Perinatal outcome i.e. low birth weight, NICU admission, low APGAR score, need of premature termination and its complications of both the groups were compared to find out predictive values of different indices(S/D ratio, PI and RI) of umbilical artery Doppler velocimetry.

Technique: Study was conducted by SONOLINE G50 model of ultrasound machine in our department. It has got two ultrasound probes with sound wave frequency of 5Mhz and 9Mhz. Doppler velocimetry obtained by 5Mhz probe trans abdominally.

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. Umbilical artery S/D ratio, RI and PI were considered abnormal when it was more than the 95th percentile of the range of reference. Absent and reverse end diastolic flow of umbilical artery Doppler were considered abnormal.

Inclusion Criteria:

1. Singleton pregnancy.
2. Diagnosed cases of hypertensive disorder of pregnancy.
3. Women with period of gestation 28 to 40 weeks.

Exclusion Criteria:

1. Multiple pregnancy.
2. Pregnancies associated with congenital anomalies of the fetus.
3. Systemic diseases like chronic hypertension, chronic renal failure, diabetes and SLE etc.

Statistical Analysis: All the data were selected randomly and tabulated, and then analyzed with appropriate statistical tools "MedCalc". Data were presented as mean with standard deviation or proportions as appropriate. Mean, median, standard deviation and variance were calculated and following statistical significance tests were applied.

1. Student's Unpaired T-test was used as the statistical tool to test for significance of observed mean differences.
2. Statistical analysis was done using "Chi – square Test".
3. Proportion test was also used for calculations.
4. 2×2 diagnostic tables were used for calculating sensitivity, specificity, NPV, PPV, etc.

A "p-value" was considered to be non-significant if > 0.05 and significant if <0.05.

Statistical methods were used to find the significance of homogeneity of study characteristics between the two groups of patients.

Their inference was as follows-

- $P > 0.05$ statistically insignificant
- $P < 0.05$ statistically significant
- $P < 0.01$ statistically highly significant
- $P < 0.001$ statistically very highly significant

Observations and Results

A total of 100 women with pregnancy induced hypertension were taken in to this study after considering inclusion and exclusion criteria. After last Doppler study, patients were divided into two groups, study group and the control group. Out of 100 the study group contains 38 women with abnormal umbilical artery Doppler indices and the control group contains 62 women with abnormal umbilical artery Doppler indices.

Table 1: Distribution on the basis of umbilical artery Doppler waveform

Doppler wave form	No. of women (n=100)	Percentage
Normal umbilical artery Doppler indices	62	62%
Abnormal umbilical artery Doppler indices	38	38%

After last Doppler evaluation in all the hypertensive women, we found 38(38%) women were having abnormal umbilical artery Doppler indices, they form study group and 62(62%) with normal Doppler were grouped as control group.

Demography

Table 2: Distribution on the basis of maternal age

MaternalAge (years)	Normal umbilical artery Doppler indices(n=62)		Abnormal umbilical artery Doppler indices(n=38)	
	No. of women	Percentage	No. of women	Percentage
21 –25years	11	17.74%	17	44.74%
26 –30years	34	54.84%	17	44.74%
31 –35years	15	24.19%	3	7.89%
36 –40years	2	3.23%	1	2.63%
Mean±s.d	28.58±3.54years		26.42±3.92years	

For test of significance we used "chi–square test". For test of significance between two mean we used "Paired |t|-test". ThemeanmaternalageinwomenwithnormalumbilicalarteryDopplerindices was 28.58±3.54 years and the mean maternal age in women with abnormal umbilical artery Doppler was 26.42±3.92 years. There was no significant difference observed between two age groups with **p value 0.1022**.

Table 3: Distribution on the basis of pre pregnancy maternal weight (kg)

Maternal weight(kg)	Normal umbilical artery Doppler indices(n=62)	Abnormal umbilical artery Doppler indices(n=38)	P value	Results
Mean±SD	55.37±6.84kg	59.61±6.53kg	0.0026	significant

For test of significance between two mean we used "Paired |t|-test". The mean maternal weight in the women with normal umbilical artery Doppler indices was 55.37 ± 6.84 kg and the mean maternal weight in women with abnormal umbilical artery Doppler was 59.61± 6.8kg. There was a statistical difference observed between two groups with p value =0.0026.

Table 4: Distribution on the basis of gravida

Gravida	Normal umbilical artery Doppler indices(n=62)		Abnormal umbilical artery Doppler indices(n=38)	
	No. of women	Percentage	No. of women	Percentage
G_1	33	53.23%	26	68.42%
G_2	14	22.58%	7	18.42%
G_3	9	14.52%	3	7.90%
$\geq G_4$	6	9.68%	2	5.26%

For test of significance we used "chi–square test". There was nonsignificant difference between the two groups based on their gravida distribution with **p value =0.4662**.

Table 5: Distribution on the basis of types of hypertensive disorder

Types of hypertensive disorder	No. of women (n=100)	Percentage
Gestational hypertension	46	46%
Mild preeclampsia	40	40%
Severe preeclampsia	14	14%

While classifying hypertensive disorder of pregnancy according to the new ACOG 2013 classification we found 46 (46%) women with Gestational Hypertension,40 (40%) women presented with mild preeclampsia with non-severe features and 14(14%) were having preeclampsia with severe features.

Table 6: Distribution on the basis of Blood Pressure at the time of delivery

BloodPressure	Normal umbilical artery Doppler indices(n=62)	Abnormal umbilical artery Doppler indices(n=38)	P value	Results
SBP (Mean ±s.d)	149.19±8.93	150.36±9.99	0.5448	Not significant
DBP (Mean ±s.d)	94.68±6.71	101.05±7.98	<0.0001	Significant

For test of significance between two mean we used "Paired |t|-test". Mean SBP and DBP in patients with normal umbilical artery Doppler indices were 149.19±8.93mm Hg and 94.68±6.71mm Hg respectively whereas the mean SBP and DBP in patients with abnormal umbilical artery Doppler were 150.36±9.99mmHg and 101.05±7.98mmHg respectively. There was statistically significant difference found between the diastolic blood pressure of two groups with p value <0.0001.

Table 7: Distribution on the basis of gestational age at the time of delivery

Gestational age at delivery(weeks)	Normal umbilical artery Doppler indices(n=62)		Abnormal umbilical artery Doppler indices(n=38)	
	No. of women	Percentage	No. of women	Percentage
28 –32.6weeks	2	3.23%	4	10.53%
33 –36.6weeks	21	33.87%	20	52.63%
≥37weeks	39	62.90%	14	36.84%
Mean±s.d	36.55±2.16weeks		35.92±2.71weeks	

For test of significance, we used "chi – square test" with p value = 0.0255, results are significant.

For test of significance between two mean we used "Paired |t|- test" with p value =0.2024, Results are not significant.

Mean gestational age at delivery was 35.92 ± 2.71 weeks in women with abnormal Doppler while it was 36.55 ± 2.16 weeks in normal Doppler group. The percentage of preterm delivery in women with abnormal umbilical artery Doppler was 63.16% whereas 37.1% of preterm deliveries were seen in those women with normal umbilical artery Doppler.

Table 8: Distribution on the basis of induction of labour

Induced labour	Normal umbilical artery Doppler indices(n=62)		Abnormal umbilical artery Doppler indices (n=38)		P value	Results
	No. of women	Percentage	No. of women	Percentage		
YES	18	29.03%	23	60.53%	0.0037	Significant
NO	44	70.97%	15	39.47%		

For test of significance between two mean we used "Paired |t|-test. The labour induction rate in case of women with abnormal umbilical artery Doppler indices was 60.53% when compared to induction rate of women with normal umbilical artery Doppler indices which was 29.03%. Hence there was statistically significant difference found with p value=0.0037.

Table 9: Distribution on the basis of mode of delivery

Mode of delivery	Normal umbilical artery Doppler indices(n=62)		Abnormal umbilical artery Doppler indices(n=38)	
	No. of women	Percentage	No. of women	Percentage
Vaginal(n=55)	38	61.29%	17	44.74%
Elective LSCS(n=17)	9	14.52%	8	21.05%
Emergency LSCS(n=28)	15	24.19%	13	34.21%

For test of significance, we used "chi – square test" with p value = 0.2711, results are not significant. It was found that 21 (55.26%) women with abnormal Doppler group delivered by caesarian section whereas caesarian

rate in normal UA Doppler group was 24(38.71%). There was statistically not significant difference seen in cae-sarian rate of both groups.

Table 10: Distribution on the basis of birth weight of the baby

Birthweight	Normal umbilical artery Doppler indices(n=62)	Abnormal umbilical artery Doppler indices(n=38)	P value	Results
Mean±SD	2.67±0.43	2.43±0.52	0.0141	significant

For test of significance between two mean we used "Paired |t|-test". Themeanbirthweightofbabiesinwomenwith-normalumbilicalarteryDoppler indices was with 2.67 ± 0.43kg and the mean birth weight in women with ab-normal umbilical artery Doppler indices was 2.43 ± 0.52 kg. Hence there was statistically significant difference found with p value=0.0141.

Table 11: Doppler velocimetry of umbilical artery and APGAR Score at 5min

APGARSCORE At 5 min	Normal umbilical artery Doppler indices(n=62)		Abnormal umbilical artery Doppler indices(n=38)		P value	Results
	No.	Percentage	No.	Percentage		
<7	6	9.68%	12	31.58%		
≥7	56	90.32%	26	68.42%	0.0125	Significant

For test of significance we used "chi–square test". It was observed that the percentage babies born with APGAR score of <7 at 5min in patients with abnormal umbilical artery Doppler indices was 31.58% and thatof patients with normal umbilical artery Doppler indices was 9.68%. Hence there was statistically significant results are found with p value=0.0125.

Table 12: Doppler velocimetry of umbilical artery and NICU stay(in days)

NICU stay (in days)	Normal umbilical artery Doppler indices(n=62)	Abnormal umbilical artery Doppler indices(n=38)		Pvalue	Results
Mean±s.d	0.76±2.37	2.68±5.20		0.0134	significant

For test of significance between two mean we used "Paired |t|-test". It was observed that the mean NICU stay in babies born to patients with abnormal umbilical artery Doppler indices was 2.68 ± 5.20days and the mean NICU stay in case of babies born to patients with normal umbilical artery Doppler indices was 0.76 ± 2.37days. Hence there was statistically significant difference found with p-value =0.0134.

Table 13: Doppler velocimetry of umbilical artery and perinatal complications

Perinatal complication type	Normal umbilical artery Doppler indices(n=62)		Abnormal umbilical artery Doppler indices(n=38)		P value	Results
	No.	Percentage	No.	Percentage		
APGAR <7(n=18)	6	9.68%	12	31.58%	0.0125	SIGNIFICANT
FGR(n=22)	9	14.52%	13	34.21%	0.0396	SIGNIFICANT
Preterm(n=48)	26	41.94%	22	57.89%	0.1791	NS
NICU stay	13	20.97%	16	42.11%	0.0419	SIGNIFICANT
RDS	6	9.68%	10	26.32%	0.0546	SIGNIFICANT
Neonatal death(n=4)	1	1.61%	3	7.89%	0.3029	NS
MAS	3	4.84%	3	7.89%	0.8496	NS
IUD	0	0%	1	2.63%	0.8043	NS

For test of significance, we used "chi–square proportion test"

Table 14: Distribution on the basis of perinatal mortality

Perinatal mortality	No. of patients	Perinatal mortality
Absent end diastolic flow (AEDF)	2	1(50%)
Reverse end diastolic flow (REDF)	1	1 (100%)

Chi=0.188, p =0.6650, not significant. Out of 38 women with abnormal Doppler 2 had AEDF with 50% perina-tal mortality and 1 had REDF with 100% mortality.

Table 15: Distribution of abnormal umbilical artery Doppler wave form

Umbilical Artery Doppler indices	No. of patients with abnormal umbilical artery Doppler indices	Adverse outcomes
UA PI	35	30 (85.7%)
UARI	28	21 (75%)
UA S/D	31	25 (80.6%)

It was observed that out of 35 women with abnormal UA PI 30 (85.7%) were having adverse perinatal outcomes and out of 28 women with abnormal UA RI 21(75%) were having adverse perinatal outcomes and lastly out of 31 women with abnormal UAS/D25(80.6%) were having poor perinatal outcomes.

Table 16: No. of patients with umbilical artery Doppler indices

Umbilical artery Doppler indices	True positive	False negative	False positive	True negative
PI	30	7	5	58
RI	21	7	7	65
S/D	25	7	6	62

Table 17: Diagnostic index of umbilical artery parameters as predictors of adverse perinatal outcomes

Umbilical artery Doppler indices	Sensitivity	Specificity	PPV	NPV	AUC
PI	81.08%	92.06%	85.71%	89.23%	0.87
RI	75%	90.28%	75%	90.28%	0.83
S/D	78.12%	91.18%	80.65%	89.86%	0.85

In our study, we observed that UAPI had highest predictive power with sensitivity of 81.08%, PPV (85.71%), and accuracy (87%) followed by UA S/D having sensitivity (78.12%), PPV (80.65%) and accuracy (85%). Specificity and NPV was nearly same for all UA Doppler indices.

Discussion

Hypertension is one of the common medical complications of pregnancy and contributes significantly to maternal and perinatal morbidity and mortality. It causes 10-15% of maternal deaths especially in developing countries [11] and responsible for 18% of fetal and infant mortality as 46% of infants born for small for gestational age [12]. Perinatal mortality is an important indicator of the quality of obstetric care during pregnancy [13,14]. Preterm birth is the most common cause of perinatal mortality, causing almost 30% of neonatal deaths. [15]

Complications of pregnancy induced hypertension which predict perinatal outcome are preterm birth, IUGR babies, placental abruption, fetal hypoxia, nonreassuring fetal status and perinatal death [14]. Predicting these complications may improve the perinatal outcome by providing appropriate antenatal surveillance and therapeutic intervention. 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. It is here that the role of color Doppler comes to detect these early stages of fetal distress by providing a unique, noninvasive and safe method of studying blood flow characteristics in both the fetoplacental and uteroplacental circulations that is being used in clinical evaluation of high risk pregnancies [16]. Doppler ultrasound helps one to identify the fetus at risk and time of delivery.

The timed diagnosis of fetal compromise is important so that delivery can be effected before fetus suffers irreversible damage and dies in utero. Doppler does correlate well with the fetal compromise giving earlier warning signs of fetal distress than other tests. Present study is an effort to establishing the role of UA Doppler ultrasound in predicting adverse perinatal outcome in hypertensive disorders of pregnancy and to determine its role in clinical management of such pregnancies.

This study is conducted in the department of Obstetrics and Gynecology, Bokaro General Hospital, Bokaro Steel City, Jharkhand, which is a 910 bedded multidisciplinary hospital. A Prospective study duly approved by ethical committee.

The patients were enrolled for the study after taking informed consent. All the pregnant women attending the antenatal clinic in Department of Obstetrics and Gynaecology in Bokaro General Hospital screened for pregnancy induced hypertension using inclusion and exclusion criteria shown above. 100 pregnant women with PIH were included in the study and they were followed till delivery and early neonatal period. In this hospital no study had been done to study "Role of umbilical artery Doppler in prediction of adverse perinatal outcomes in hypertensive disorders of pregnancy", so this study is chosen.

A total of 100 women with pregnancy induced hypertension were taken into this study after considering inclusion and exclusion criteria. After last Doppler study, patients were divided into two groups, study group and the control group.

Out of 100 the study group contain 38 women with abnormal umbilical artery Doppler indices and the control group contain 62 women with abnormal umbilical artery Doppler indices.

Table 18: Distribution on the basis of umbilical artery Doppler wave form

Doppler waveform	Present study	Mahmoud Alalfy et-al(2019) [20]	Anjuri J. Roy et al (2018) [21]	Jyoti Yadav et al(2017) [23]	Santosh Kumar Singh et al(2017) [26]	Aharwal S et al(2016) [27]
Normal	62%	58%	43.3%	64%	37%	65.8%
abnormal	38%	42%	56.7%	36%	63%	34.2%

In our study out of 100 women with PIH, 62% of women showed normal umbilical artery Doppler and 38% showed abnormal Doppler which was comparable with studies done by Mahmoud Alalfy et al(2019) [20], Jyoti Yadav et al(2017) [23] and Aharwal S et al(2016) [27], whereas study done by Anjuri J. Roy et al (2018) [21] showed 43.3% of normal Doppler and 56.7% of abnormal Doppler and study done by Santosh Kumar Singh et al (2017) [26] showed 37% of normal Doppler and 63% of abnormal Doppler.

Table 19: Distribution on the basis of maternal age (Table No. 02)

Study	Mean maternal age in years
Present study	27.76
Ritu Mishra et al(2020) [19]	25.7
Mahmoud Alalfy et al(2019) [20]	30.0±5.9
Jyoti Yadav et al(2017) [23]	26.9±4.14
Santosh Kumar Singh et al (2017) [26]	22.8±3.6
Pradip R et al(2017) [25]	26.9

Hypertension in pregnancy affects women of all ages. In our study the mean maternal age was 27.76years which was comparable with above studies.

Distribution on the basis of pre pregnancy maternal weight (kg) (Table No. 03): Pre pregnancy BMI/weight is an independent risk adverse effect the present study showed mean maternal weight of 55.37±6.84 kg in women with normal umbilical artery Doppler and 59.61± 6.53kg kg in women with abnormal umbilical artery Doppler.

Study done by Jyoti Yadav et al(2017) [23] according to pre-pregnancy BMI 24% women were overweight and 38% were obese.

Table 20: Distribution on the basis of gravida (Table No. 04)

Study	Primigravida (%)	Multigravida (%)
Present study	59	41
Ritu Mishra et al(2020) [19]	41.4	58.43
Anjuri J. Roy et al (2018) [21]	54.7	45.3
Jyoti Yadav et al(2017) [23]	64	36
Pradip R e tal(2017) [25]	54.72	45.28
Santosh Kumar Singh et al (2017) [26]	69	31
Swapnali C. Kshirsagar et al(2016) [28]	54	46
Arathi AP et al(2013) [31]	52.1	47.8

The immunologic theory supports that hypertension is most commonly a disease of 1st pregnancy. In our study also primi gravida were more than multi gravida with 59% versus 41% and it was comparable with above studies except study done by Ritu Mishra et al(2020) [19] where multi gravida were more than primi gravida.

Table 21: Distribution of percentage of patients on the basis of type of hypertensive disorder

Type of hypertensive disorder	Present study	Mahmoud Alalfy et al.(2019) [20]	Jyoti Yadav et al. (2017) [23]
Gestational hypertension	46%	16%	48%
mild preeclampsia	40%	28%	39%
Severe preeclampsia	14%	56%	13%

In our study out of 100 PIH patients, 46% of women had gestational hypertension, 40% had mild preeclampsia and 14% had severe preeclampsia which was comparable with study done by Jyoti Yadav et al(2017) [23].

Study done by Mahmoud Alalfy et al (2019) [20] showed 16% of gestational hypertension, 28% of mild preeclampsia and 56% of severe preeclampsia which was not comparable with the present study may be due to sample size and geographical variation.

Distribution on the basis of Blood Pressure at the time of delivery (table no.06)

Early gestational hypertension shares with pre eclampsia a high incidence of poor placentation with histological evidence of placental ischemia. UA Doppler reflects placental function and indicates the degree of placental insufficiency. In present study mean SBP and DBP of normal Doppler group is 149.19±8.93 and 94.68±6.71 respectively. Mean SBP and DBP of abnormal Doppler group is 150.36±9.99 and 101.05±7.98 respectively.

Table 22: Distribution on the basis of gestational age at the time of delivery

Gestational age at delivery	Present study	Anjuri J. Roy et al (2018) [21]	Jyoti Yadav et-al(2017) [23]	Pradip R et-al(2017) [25]
28-33.6	**11%**	-	17%	
34-36.6	**36%**	33.3%	31.5%	25.46%
37-40	**53%**	64.7%	51.5%	74.53%

Present study shows 11% of women had 28-33.6 weeks of gestational age at the time of delivery, 36% and 53% of women had 34-36.6 weeks and 37-40 weeks of gestational age respectively at the time of delivery which is comparable with the study done by Jyoti Yadav et al(2017) [23] whereas study conducted by Anjuri J. Roy et al (2018) [21]showed 33.3% of women with gestational age 34-36.6 weeks and 64.7% with 37-40 weeks of gestational age.

Study conducted by Pradip R et al(2017) [25] showed 25.46% of women with gestational age of 28-33.6 and 74.53% of women with 37-40 weeks of gestational age.

Table 23: Distribution on the basis of induction of labour

Study	Percentage of induced labour	
	Normal Doppler	Abnormal Doppler
Present study	**29.03%**	**60.53%**
Anjuri J. Roy et al (2018) [21]	30%	
Jyoti Yadav et al(2017) [23]	31.25%	61.11%
Jyoti Devi et al(2017) [24]	29.03%	57.89%
Swapnali C. Kshirsagar et al(2016) [28]	48%	

In present study 29.03% of women with normal Doppler were induced and 60.53% of abnormal Doppler women are induced. Induction rate of our study was comparable with the studies done by Jyoti Yadav et al(2017) [23] and Jyoti Devi et al(2017) [24]. Study done by Anjuri J. Roy et al (2018) [21] had overall lesser induction rate compared to the present study. Study done by Swapnali C. Kshirsagar et al (2016) [28] had 48% of induction rate.

Table 24: Distribution on the basis of mode of delivery

Study	Vaginal delivery		LSCS	
	Normal Doppler	Abnormal Doppler	Normal Doppler	Abnormal Doppler
Present study	**61.29%**	**44.74%**	**38.71%**	**55.26%**
Mahmoud Alalfy et al(2019) [20]	14.3%	43.1%	85.7%	56.9%
Jyoti Yadav et-al(2017) [23]	67.18%	47.22%	32.8%	52.77%

In present study, out of 62 women with normal umbilical artery indices, 61.29% had vaginal delivery, 14.52% and 24.19% had elective an emergency LSCS respectively. 44.74%, 21.05% and 34.21% of women had vaginal delivery, elective LSCS an emergency LSCS respectively among 38 women with abnormal umbilical artery indices. The main indications for LSCS were Doppler changes, meconium stained amniotic fluid, severe oligohydramnios, fetal distress or non-reassuring fetal heart rate patterns and severe preeclampsia. Vaginal delivery rate and LSCS rate in abnormal Doppler group of present study were comparable with above studies.

Table 25: Distribution on the basis of birth weight of the baby (kg)

Study	Normal Doppler	Abnormal Doppler
Present study	**2.67±0.43 kg**	**2.43±0.52kg**
Mahmoud Alalfy et al(2019) [20]	3.23±.12kg	2.65±.37kg
Rashmi L et al(2018) [22]	2.86kg	2.29kg

The mean birth weight of babies born to women with normal Doppler was 2.67±0.43 kg and that of those with abnormal umbilical artery Doppler was 2.43±0.52kg. The mean birth weight of babies delivered to women with abnormal Doppler indices was lower which was comparable with the above studies.

Table 26: Doppler velocimetry of umbilical artery and APGAR <7 Score at 5 min (Table No.11)

Study	APGAR<7	
	Normal Doppler	**Abnormal Doppler**
Present study	**9.68%**	**31.58%**
Anjuri J.Roy et al (2018) [21]	49.3%	
Jyoti Devi et al(2017) [24]	19.35%	47.36%
Jyoti Yadav et al(2017) [23]	14.06%	23.61%
Santosh Kumar Singh et al (2017) [26]	2.7%	50.7%
Pradip R et al(2017) [25]	16.03%	

In our study APGAR score <7 at 5min results showed that 9.68% of babies born to women with normal UA Doppler and 31.58% of babies born to women with abnormal UA Doppler. More number of low APGAR scores were seen in those with abnormal UA Doppler which was comparable with studies done by Jyoti Devi et al(2017) [24], Jyoti Yadav et al(2017) [23] and Santosh Kumar Singh et al (2017) [26]. Studies done by Anjuri J. Roy et al (2018) [21] and Pradip R et al(2017) [25] showed 49.3% and 16.03% of low APGAR among all patients.

Table 26: Doppler velocimetry of umbilical artery and perinatal complications in percentage

Perinatal complication type	Present study		Anjuri J.Roy et al (2018) [21]	Jyoti Devi et al(2017) [24]		Jyoti Yadav et al(2017) [23]		Santosh Kumar Singh et al(2017) [26]		Pradip R et al (2017) [25]
	Normal Doppler	**Abnormal Doppler**		**Normal Doppler**	**Abnormal Doppler**	**Normal Doppler**	**Abnormal Doppler**	**Normal Doppler (PI)**	**Abnormal Doppler (PI)**	
APGAR<7(%)	**9.68**	**31.58**	49.3	19.35	47.36	14.06	23.61	2.7	50.7	16.03
FGR (%)	**14.52**	**34.21**	50.0	22.58	52.63	16.40	31.94	58.7	21.6	34.9
Preterm (%)	**41.94**	**57.89**	33.3	29.03	57.89	39.06	65.27	40		25.4
NICU stay(%)	**20.97**	**42.11**	53.1	25.80	47.36	17.96	33.33	18.9	73	14.15
RDS (%)	**9.68**	**26.32**	-	-	-	-	-	-		-
Neonatal death(%)	**1.61**	**7.89**	5.33	0	5.2	0.78	4.16	-		0.94
MAS (%)	**4.84**	**7.89**	-	-	-	4.68	6.94	-		-
IUD/ Still birth(%)	**0**	**2.63**	4.0	0	15.78	0	2.77	-		1.88

In our study overall perinatal outcome was poor in patients with abnormal UA Doppler which was comparable with above studies.

Table 27: AEDF, REDF and perinatal mortality

Study	Mortality in %(AEDF)	Mortality in %(REDF)
Present study	**50**	**100**
Jyoti Yadav et al(2017) [23]	66.66	100
Jyoti Devi et al(2017) [24]	66.66	100
Padmini C.P et al (2016) [29]	75	100
Smitha K et al(2014) [30]	27.78	100

In our study there is 50% mortality in AEBF and 100% mortality in REDF. There was 100% mortality seen in women with REDF which was comparable with above studies.

Table 28: Distribution of abnormal umbilical artery Doppler indices

Umbilical Adverse indices	Present study	Mahmoud Alalfy et al(2019) [20]	Jyoti Yadav et al(2017) [23]	Santosh Kumar Singh et al(2017) [26]	Pradip R et al(2017) [25]
PI	**35%**	58%	36%	63%	15%
RI	**28%**	-	31.5%	58%	26%
S/D	**31%**	-	32.5%	52%	20%

Present study shows 35% of abnormal PI, 28% of abnormal RI and 31% of abnormal S/D ratio which is comparable with study done by Jyoti Yadav et al(2017) [23]. Study done by Santosh Kumar Singh et al (2017) [26] showed 63%, 58% and 52% of abnormal PI, RI and S/D ratio respectively. Study done by Pradip R et al(2017) [25] showed 15%, 26% and 20% of abnormal PI, RI and S/D ratio respectively. Study done by Mahmoud Alalfy et al(2019) [20] showed 58% of abnormal PI.

Table 29: Predictive values of umbilical artery Doppler indices in predicting the adverse perinatal outcome

Author	Index(%)	SS(%)	SP(%)	PPV(%)	NPV(%)	Accuracy(%)
Present study	**PI**	**81.08**	**92.06**	**85.71**	**89.23**	**87**
	S/D	**78.12**	**91.18**	**80.65**	**89.86**	**85**
	RI	**75**	**90.28**	**75**	**90.28**	**83**
Jyoti Yadav et al(2017) [23]	PI	84.21	93.54	88.88	90.62	90
	S/D	80.64	88.54	76.92	90.62	86.5
	RI	77.35	87.21	73	90.62	85.5
Pradip R et al(2017) [25]	PI	29.73	92.75	68.75	71.11	70.75
	S/D	40.54	89.86	68.18	73.81	72.64
	RI	37.84	79.71	50	70.51	65.09
Jyoti Devi et al(2017) [24]	PI	68.75	88.23	73.33	85.71	66
	S/D	76.19	89.65	84.21	83.87	76
	RI	64.28	88.88	73.33	85.71	62
Padmini C. Petal (2016) [29]	PI	75	98.3	93.3	92.2	-
Smitha K et al(2014) [30]	PI	90.26	80.57	82.24	88.35	-

In our study, we observed that UA PI had highest predictive power with sensitivity of 81.08%, PPV (85.71%), and accuracy (87%) followed by UA S/D having sensitivity (78.12%), PPV (80.65%) and accuracy (85%). Specificity and NPV was nearly same for all UA Doppler indices and the results are comparable with study done by Jyoti Yadav et al(2017) [23].

Study done by Jyoti Devi et al(2017) [24] showed the UA S/D was more sensitive, specific and had a higher predictive power in predicting adverse perinatal outcome.

Study done by Pradip R et al(2017) [25] showed UA S/D had more sensitivity and UA PI had more specificity and PPV in predicting adverse perinatal outcome.

Study done by Padmini C. P et al (2016) [29] showed UA PI had more specificity and PPV than sensitivity in predicting adverse perinatal outcome.

Study done by Smitha K et al(2014) [30] showed UA PI had more sensitivity than specificity in predicting adverse outcomes.

Conclusion

The following conclusions were drawn after the study.

- Abnormal UA Doppler predicts adverse perinatal outcomes in women with hypertensive disorders of pregnancy.
- Doppler velocimetry has proved to reliably detect early fetoplacental compromise in hypertensive pregnancies and can be a useful tool for taking decision in the appropriate timing of

intervention for delivery thereby reducing perinatal morbidity and mortality.

- Out of three Doppler indices UA PI had highest sensitivity, specificity, PPV and good accuracy with less false positive rates in predicting adverse perinatal outcome.

References

1. James PR, Nelson-Piercy C. Management of hypertension before, during, and after pregnancy. Heart. 2004; 90:1499-1504.
2. Khan KS, Wojdyla D, Say L, et al. WHO analysis of causes of maternal death: a systemic review. Lancet. 2006; 367:1066-1074.
3. Henry, C.S., Biedermann, S.A., Campbell, M.F. and Guntupalli, J.S. Spectrum of Hypertensive Emergencies in Pregnancy. Critical Care Clinics, 2004;20: 607-712.
4. Wallis AB, Saftlas AF, Hsia J, et al. Secular trends in the rates of preeclampsia, eclampsia, and gestational hypertension, United States, 1987–2004. Am J Hypertens. 2008; 21:521–526.
5. Berg CJ, Mackay AP, Qin C, et al. Overview of maternal morbidity during hospitalization for labor and delivery in the United States: 1993–1997 and 2001– 2005. Obstet Gynecol. 2009; 113:1075–1081.
6. Berg CJ, Harper MA, Arkinson SM, et al. Preventability of pregnancy-related deaths. Obstet Gynecol. 2005; 106:1228–1234.
7. Cantwell R, et al. Saving Mothers' Lives: Reviewing maternal deaths to make motherhood safer: 2006–2008. The Eighth Report of the Confidential Enquiries into Maternal Deaths in

the United Kingdom. Brit J Obstet Gynecol. 2011;118, Suppl 1:1–203.

8. National Institute of Health and Clinical excellence. 2010. Hypertension in pregnancy: The management of hypertensive disorders during pregnancy. CG no. 107. London, UK: National Institute of Health and Clinical excellence.

9. Report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy. Am J Obstet Gynecol 2000;183: S1–S22. [PubMed]

10. Fiona M, Chris R, James W, et al. The pre-eclampsia community guideline (PRECOG): How to screen for and detect onset of pre-eclampsia in the community. BMJ. 2005; 30: 576-580.

11. Yucesoy G, Ozkan S, Bodur H. Maternal and perinatal outcome in pregnancies complicated with hypertensive disorder of pregnancy: a seven-year experience of a tertiary care center. Arch Gynecol Obstet. 2005; 273:43-9.

12. Montan S, Sjoberg O, Svenningsen N. hypertension in pregnancy-fetal and. infant outcome Clin Exp Hypertenc. 1987; B62:337-48.

13. Richardus JH, Graffmans WC, Verloove-Vanhorick SP. &Mackenbach JP. The perinatal mortality rate as an indicator of quality of care in international comparisons. Medical care. 1998; 36: 54-66.

14. Richardus J. H. et al. Differences in perinatal mortality and suboptimal care between 10 European regions: results of an international audit. BJOG: An International Journal of Obstetrics & Gynecology. 2003; 110: 97-105.

15. March of Dimes_ Neonatal Death: Retrieved on November 10, 2014.

16. Peeters LH, Sheldon RE, Jones MD. Blood flow to fetal organs as a function of arterial oxygen content. Am J Obstet Gynecol. 1979; 135:637-46.

17. Thaler I, Manor D, Itskovitz J, Rottem S, Levit N, Timor-Tritsch I et al. Changes in uterine blood flow during human pregnancy. Am J Obstet Gynecol. 1990 Jan;162(1):121-5.

18. Schulman H, Fleischer A, Stern W, Farmakides G, Jagani N, Blattner P. Umbilical velocity wave ratios in human pregnancy. Am J Obstet Gynaecol. 1984 Apr;148(7):985-90.

19. Ritu Mishra, Aditya P. Misra. 'Role of Obstetric Colour Doppler Studies in Predicting Perinatal Outcome in Pregnancy Induced Hypertension', International Journal of Reproduction, Contraception, Obstetrics and Gynaecology, March 2020; 9(3): 1073-1078.

20. Alalfy M and Eltaieb E. The Value Fetal Umbilical Artery and Middle Cerebral Artery Doppler Indices in Women with Pregnancy Induced Hypertension in the Prediction of Adverse Perinatal Outcome. Austin J Obstet Gynecol. 2019; 6(2): 1138.

21. Anjuri J. Roy. 'Role of Color Doppler in predicting perinatal outcome in preeclampsia', International journal of Reproduction, Contraception, Obstetrics and Gynaecology, 2018; 7(2): 652-658.

22. Rashmi L., Ashish Bhattacharjee. 'Umbilical artery Doppler indices in relation to fetal outcome in high-risk pregnancy', International Journal of Reproduction, Contraception, Obstetrics and Gynecology, 2018; 7(2): 628-634.

23. Jyoti Yadav, Mala Shukla, Jain PK, Devender Kumar. 'Role of umbilical artery Doppler velocimetry in predicting the adverse perinatal outcomes in hypertensive disorder of pregnancy', International Journal of Reproduction, Contraception, Obstetrics and Gynecology, 2017;6(10): 4382-4388.

24. Jyoti Devi, Devender Kumar, Mala Shukla, P. K. Jain3 (2017) 'Doppler interrogation of fetoplacental circulation in hypertensive disorder of pregnancy and their perinatal outcomes ', International Journal of Research in Medical Sciences, 2017;5(6): 2687-2693.

25. Pradip R. Gaikwad, Manisha R. Gandhewar, Nity Rose, Vidyadhar Suryakar. 'Significance of obstetric Doppler studies in prediction of perinatal outcome in pregnancy induced hypertension', International Journal of Reproduction, Contraception, Obstetrics and Gynecology, 2017;6(6): 2354-2360.

26. Santosh Kumar Singh, Priti Mishra. 'Doppler study of umbilical and fetal middle cerebral artery in severe preeclampsia and intra uterine growth restriction and correlation with perinatal outcome', International Journal of Reproduction, Contraception, Obstetrics and Gynecology, 2017;6(10): 4561-4566.

27. Aharwal S, Agrawal R, Sharma S3. 'A study of role of Doppler ultrasound in Pregnancy induced hypertension (PIH) and perinatal outcome, International Journal of Medical Research and Review, 2016;4(4): 673-680.

28. Swapnali C. Kshirsagar, Sneha S. Shirodkar, Sunil J. Yadav, Umesh M. Zile. 'Role of Doppler indices in prediction of perinatal outcome in preeclampsia', International Journal of Reproduction, Contraception, Obstetrics and Gynecology, 2016;5(10): 3390-3397.

29. Padmini C. P., Priyanka Das, Chaitra R., M. Sriram Adithya. 'Role of Doppler indices of umbilical and middle cerebral artery in prediction of perinatal outcome in preeclampsia', International Journal of Reproduction, Contraception, Obstetrics and Gynecology, 2016; 5(3): 845-849.

30. Smitha K, Sowmya K, Malathi T (2014) 'Study of Doppler waveforms in pregnancy induced hypertension and its correlation with perinatal outcome, International Journal of Reproduc-

tion, Contraception, Obstetrics and Gynecology, 2014; 3(2): 428-433.

31. Arathi A P, Jyothi H Rao and Ashwini A P. 'A clinical study of role of colour Doppler imag-ing in pregnancies at risk', International Journal of Biomedical Research, 2013; 4(9): 477-480.