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A PROSPECTIVE STUDY ON EVALUATION OF DOPPLER ULTRASOUND APPLICATION IN OBSTETRICS WITH BLOOD FLOW VELOCITY WAVEFORM IN PREGNANCY-INDUCED HYPERTENSION.

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ABSTRACT.

Aim:
This study aims to illustrate that the speed of blood flow can be determined using Doppler ultrasound which can be useful in obstetrics for determining the blood flow in pregnant women having hypertension.

Methods:
The present research was a prospective multicenter investigation including a cohort of 50 pregnant women diagnosed with pregnancy-induced hypertension (PIH). These individuals were subjected to sonographic evaluation using Doppler color imaging techniques. The research was carried out in the Department of Obstetrics and Gynaecology. The duration of the research spanned 16 months.

Results:
The cases of PIH were categorized into age groups of > 20, 20-24, 25-29, and 30-34 years. The bulk of the cases fell within the age category of 20-24, accounting for approximately 40% of the total cases. The average age of the participants was 25.5 years. A total of 34% of the reported cases were observed within the age group of 25-29. Within this study, it was observed that among the group of pregnant individuals with hypertension, 20 individuals (40%) were nulliparous, whereas 22 individuals (44%) were primiparous. The remaining 14% of cases were classified as multipara. Among the instances of Pregnancy-Induced Hypertension (PIH) that were examined, it was observed that out of a total of 50 cases, 32 cases exhibited aberrant uterine artery Doppler indices, representing 64% of the sample.

Conclusion:
Doppler ultrasound can detect cases of pregnancy-induced hypertension at an early stage of pregnancy through a reliable and non-invasive assessment of hemodynamic function. The utilization of Doppler indices obtained from fetal circulation has demonstrated a consistent ability to accurately forecast bad perinatal outcomes in obstetric patients, particularly those belonging to high-risk populations.

Recommendation:
Low-dose aspirin is recommended in patients with chronic hypertension in pregnancy from between 12- and 28 weeks gestation to delivery.

Keywords: Doppler ultrasound, Pre-eclampsia, Uteroplacental flow, pregnancy-induced hypertension
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INTRODUCTION.

Preeclampsia has been the cause of 6% of fetal deaths and the restriction of fetal growth has caused about 10% of the fetal deaths. Contemporary antenatal care delivery is centered around employing a risk-oriented methodology to oversee and detect any adverse pregnancy consequences, including but not limited to preeclampsia, fetal growth restriction, placental abruption, and stillbirth. There is a growing focus in research on the timely detection of potential dangers, enabling the implementation of management techniques at an early stage to mitigate the likelihood of negative outcomes. This includes the

promotion of adequate levels of monitoring during pregnancy.[1]

Preeclampsia is a medical disorder that manifests after the 20th week of pregnancy, characterized by the presence of hypertension and proteinuria, with or without edema, in a woman who previously had normal blood pressure levels. Pregnancy-related problems are prevalent and pose significant risks to the health and well-being of both the mother and fetus, particularly in underdeveloped nations.[2-4] If left untreated, preeclampsia will advance to eclampsia, a condition marked by high blood pressure and seizures characterized by muscle stiffness and jerking movements.[5] The global prevalence of preeclampsia exhibits significant variation, with reported rates ranging from 2% to 10% across different regions.[6] As per WHO, the occurrence of preeclampsia is almost seven times greater in developing nations, with a prevalence of 2.8% among live births, in comparison to industrialized nations where the prevalence is 0.4%.6

The identification of maternal uterine arteries by ultrasonography can be achieved with high accuracy and consistency by utilizing color sonography and assessing the blood flow resistance index in conjunction with Doppler. As a woman advances in her pregnancy the blood flow in the uterine arteries increases. This phenomenon is believed to be caused by the gradual invasion and alteration of the uterine spiral arteries by trophoblastic cells, resulting in the development of larger vessels with lower resistance.[7] The occurrence of failure to transform has been extensively seen in instances of preeclampsia and fetal growth restriction, resulting in the use of interventions targeting uterine artery blood flow. The use of Doppler measurement as a screening technique for identifying problems during pregnancy.[8] A recent meta-analysis examining various screening methods for preeclampsia revealed that the Doppler method for evaluating the artery of the uterine as an independent diagnostic tool exhibited the highest predictive efficacy for early-onset preeclampsia, surpassing other tests such as increased placental growth factor (PLGF), body mass index (BMI) and placental protein 13 (PP13), which demonstrated only moderate predictive value. The investigation also demonstrated that none of the individual biomarkers satisfied the necessary criteria for clinical testing. However, models that integrated multiple indicators showed greater potential for predicting the occurrence of preeclampsia.[9]

This study aims to provide a comprehensive account of the practical use of Doppler ultrasound in the field of obstetrics, specifically focusing on the measurement of blood flow velocity waveform when hypertension occurs during pregnancy.

MATERIALS AND METHODS.

Study Design, Duration, and Location.

This prospective study examines 50 gestating women diagnosed with hypertension during pregnancy across several centers. The participants were assessed using sonographic techniques with the inclusion of color Doppler. The research was carried out in the Department of Obstetrics and Gynaecology, Sumitram Hospital, Bidupur Bazar, Vaishali, Bihar, and the Department of Radiodiagnosis, SKMCH, Muzaffarpur, Bihar, India, spanning 16 months.

Inclusion Criteria.

The research comprised pregnant women who had reached a gestational age of more than 24 weeks and were diagnosed with pregnancy-induced hypertension. The reference criteria considered acceptable for diagnosing Pregnancy Hypertension (PIH) include consistently elevated systolic blood pressure greater than 140 mm Hg or diastolic blood pressure greater than 90 mm Hg, with or without the presence of protein in the urine greater than 0.3 g of protein in the urine collected in 24 hours occurring for the first time after 20 weeks of gestation.

Exclusion Criteria.

Pregnancies characterized by serious congenital anomalies were omitted from the research.

Data Collection and Analysis.

The age of individuals in the gestational hypertension group spanned from 19 to 33 years, who were pregnant for 25 weeks to 39 weeks. The gestational age of all participants was verified using 2-D, B mode ultrasonography to estimate the Femur length (FL), Bi-parietal diameter (BPD), and abdominal circumference (AC) of the fetus. Subsequently, the subjects were examined using color Doppler. The first observations were duly considered during the first assessment. Doppler investigations were conducted as needed, with repetition as necessary. The participants in the study were monitored until the point of birth, and information on the delivery itself as well as the ultimate perinatal outcome was gathered.

Measurements were taken on a Doppler scan conducted when the mother was in a supine posture, namely during periods of fetal inactivity and apnea. The patient's gestational age was calculated using a B mode 2-D 3.5-5 MHz convex probe, and a Doppler scan was performed using the pulsed Doppler method. Initially, the necessary data including the Femur length (FL), Biparietal diameter (BPD), Abdominal circumference (AC), and Mean gestational age (MGA) were gathered. Subsequently, a color Doppler examination was performed.

Artery in the uterus: The investigation commenced by initially determining the location of the placental site, followed by an examination of the Uterine artery. In cases when the placenta exhibits unilateral characteristics, the

uterine artery on the corresponding side was examined. When encountering a central placenta, an assessment was conducted on both uterine arteries. The primary division of the artery in the uterus is situated near the cervical region. The examination of the uterine artery was conducted at the internal os level, where it was observed to intersect the external iliac artery at a perpendicular angle when the bladder was fully distended. A Doppler velocimetry measurement was conducted near this geographical location. The positioning of the probe was optimized to get high-quality signals from the uterine artery, which were identified based on their distinctive flow and the sound occurring from it. When the display exhibited many waveforms that shared comparable amplitude and configuration, a single image was selected and specific points corresponding to the peak of systole and end of diastole velocities were identified using cursors. The Pulsatility Index, Resistive Index, and S/D ratio were measured and recorded.

Umbilical artery: The goal of this research was to examine an umbilical cord as in the loop to assess the umbilical artery. The values obtained at the mid-cord or placental implantation were selected due to their clinical reliability. The probe is placed such that there is a minimum disturbance in the signals received from the umbilical cord. Precautions were implemented to avoid collecting data on gross body movements while doing fetal breathing measurements. When the display exhibits multiple waveforms that share comparable amplitude and pattern, a single image was selected, and specific points of interest, such as maximum systole and the end of diastole velocities, were identified using cursors.

Middle cerebral artery: The middle cerebral artery was observed transversely of the fetal skull. A transverse imaging modality was utilized to capture a visual representation of the fetal brain, namely at the level corresponding to the biparietal diameter. Subsequently, the transducer is positioned in proximity to the cranial base. Color flow imaging allows for visualization of the middle cerebral artery. This artery is observed to run anterolaterally along the border between the anterior and middle cerebral fossae. Flow velocity waveforms are obtained by placing the pulsed Doppler sample gate on the central section of the vessel. During the study, precautions were made to ensure that the transducer applied minimum pressure on the maternal belly. This was done because it has been observed that fetal head compression can lead to changes in the waveform of intracranial arteries.

Ductus venosus: A midsagittal longitudinal plane of the fetal spine or a diagonal transverse plane across the upper abdomen may be used to see the ductus venosus. The volume sample was placed at the origin of the umbilical vein, where the highest velocities were revealed by color Doppler. Grey-scale Doppler ultrasound imaging identifies the presence of a tiny vessel that connects the umbilical vein (UV) with the inferior vena cava (IVC). The vessel located anterior to the fetal aorta has the highest brightness on color/flow imaging due to the presence of aliasing, which is caused by turbulent flow. The study examined various factors related to pregnancy outcomes, including the method of delivery, whether the delivery was preterm or full-term, the occurrence of intrauterine growth retardation, the birth weight of the infant, the Apgar score, instances of intrauterine fetal death, and perinatal mortality.

Bias.

There was a chance that bias would arise when the study first started, but we avoided it by giving all participants identical information and hiding the group allocation from the nurses who collected the data.

Ethical considerations.

The ethical aspects of the research were carefully thought out to preserve patient privacy and confidentiality.

RESULTS.

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Table 1: Number of pregnancy-induced hypertension patients based on age, parity, and uterine artery.

Age in years	N%
<20	4 (2)
20-24	20 (40)
25-29	17 (34)
30-34	9 (18)
Parity	
0	20 (40)
1	22 (44)
2	6 (12)
3 or more	2 (4)
Artery in the uterus	
Bilateral abnormal	17 (34)
Unilateral abnormal	15 (30)
Normal	18 (36)

The cases of PIH were categorized into age groups of > 20, 20-24, 25-29, and 30-34 years. Most of the cases belonged to the age group of 20-24, accounting for approximately 40% of the total cases. The average age of the subjects is 25.5 years. A total of 34% of the reported cases were identified within the age group of 25-29. In this study, it was observed that among the group of pregnant women with hypertension, 20 patients (40%) were nulliparous, whereas 22 patients (44%) were primiparous. The remaining 14% of cases were classified as multipara. Among the instances of pregnancy-induced hypertension (PIH) examined it was found that 32 of them exhibited abnormality in the artery of the uterus, representing 64% of the total. Conversely, 18 cases demonstrated normal arteries.

Table 2: Case distribution by normal and abnormal Middle and umbilical cerebral artery Indices.

Waveform-MCA	N%
Increase Diastolic Flow	30 (60)
Normal	20 (40)
Waveform-UA	
Normal	32 (64)
Decreased diastolic flow	12 (24)
Absent diastolic flow	4 (2)
Reversal of diastolic flow	2 (1)

In our investigation of instances involving pregnancy-induced hypertension (PIH), we observed that out of a total of 50 cases, 30 cases exhibited abnormal Middle cerebral artery Doppler indices, representing 60% of the cases. These abnormal indices were characterized by an increase in diastolic flow accompanied by a brain-sparing effect. Conversely, the remaining 20 cases showed normal Middle cerebral artery Doppler indices, accounting for 40% of the cases. In the context of perinatal infectious hepatitis (PIH), our study examined a total of 50 cases. Among these cases, 18 exhibited abnormal umbilical artery Doppler indices, representing 36% of the whole sample. Conversely, 32 had normal arteries, which was 64% of the sample.

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Table 3: Ductus Venosus wave reversal distribution.

Ductus venosus Waveform	N%
Reversal of a wave	8 (16)
Normal	42 (84)

In the context of perinatal infectious hepatitis (PIH), our study observed a total of 50 instances. Among these cases, 8 individuals exhibited a reversal of a wave in the waveform of the Ductus Venosus, representing 16% of the sample. Conversely, the remaining 42 cases demonstrated a normal Ductus Venosus Doppler waveform, accounting for 84% of the sample.

Table 4: Birth weight and abnormal/normal uterine artery indices.

Uterine Artery	Birth Weight (In gms)				Total
	<1000	1001-1500	1501-2500	>2500	
Bilateral abnormal	5 (29.42)	2 (11.76)	7 (41.17)	4 (23.52)	17 (100)
Unilateral abnormal	2 (13.34)	0	8 (53.33)	5 (33.33)	15 (100)
Normal	0	2 (11.11)	5 (27.77)	11 (61.12)	18 (100)
Total	7 (14)	4 (8)	20 (40)	19 (38)	50

Among the 18 instances seen in the normal uterine artery (N), the majority, namely 11 cases (61.12%), had a birth weight of more than 2500 grams, which is considered normal. None of the cases had a birth weight below 1000 grams. Among the 15 instances exhibiting unilateral uterine artery anomaly (U), it was observed that 2 cases, accounting for 13.34% of the total, had a birth weight below 1000 grams. Out of the total number of cases seen, 8 instances, accounting for 53.33% of the sample, were identified as low birth weight, falling within the range of 1500-2500 grams.

DISCUSSION.

The minor outcomes observed in this study encompassed cesarean birth due to fetal distress, APGAR scores below 7 at 5 minutes, and the need for admission to the newborn intensive care unit. Additional examples of placental complications include placental infarcts and placental abruption. The primary objectives of prenatal testing encompass the identification of fetuses that exhibit an elevated risk for perinatal morbidity and mortality.

The hypertensive condition of pregnancy is a prevalent issue that impacts the course of human gestation. This factor is considered to be a significant contributor to both maternal and fetal death and morbidity.[10] It constitutes approximately 7-10% of the total number of pregnancies. Pregnancy Induced Hypertension (PIH) encompasses 3 distinct conditions: Pre-eclampsia, Gestational hypertension, and Eclampsia. Pregnancy-induced hypertension (PIH) is associated with a range of problems. Intrauterine growth retardation (IUGR) is the prevailing consequence associated with pregnancy-induced hypertension (PIH). Perinatal deaths encompass a range of adverse outcomes, such as intrauterine and early neonatal mortality, as well as specific conditions such as hypoxia ischemic encephalopathy, periventricular leukomalacia, intraventricular hemorrhage, pulmonary hemorrhage, and necrotizing enterocolitis.

The timely identification of diseases would result in enhanced outcomes, as it enables heightened monitoring and the use of preventive treatments like low-dose aspirin.[11,12] The placenta, by the process by which it implants and develops, alters the uterine circulation by transitioning it from a state characterized by low flow and high resistance to one characterized by high flow and low resistance. The main factor that increases the likelihood of uteroplacental complications during pregnancy seems to be a deficiency in trophoblastic invasion, either partial or total.[13]
Although PIH instances were found in people of all ages (> 20, 20-24, 25-29, and 30-34), almost 40% were found in people aged 20-24. The average participant's age was 25.5 years. Among those aged 25–29, 34% were affected. Twenty (40%) of the women in the hypertensive pregnancy group were multiparous, whereas twenty-two (44%) were first-time mothers. Only 14% of pregnancies were mono para. with the fifty instances with PIH, sixty-four (64%) exhibited aberrant uterine artery Doppler indices, whereas thirty-eight (36%) had normal indices. Out of 50 patients with PIH, 30 (60%), exhibiting enhanced diastolic flow with brain-sparing effect, showed aberrant Middle cerebral artery indices. While the Doppler indices in the middle cerebral artery were normal in 20 patients (40%).

A prospective study to evaluate the utility of uterine artery color Doppler waveform analysis in predicting adverse pregnancy outcomes, including preeclampsia, intrauterine growth retardation, placental abruption, or a combination of these outcomes, in a sample of 52 high-risk pregnancies. A

study conducted by Jackson et al. (2015), it was found patients with the presence of uterine artery notches and high resistance flow were associated with significantly higher rates of fetal development restriction and c-section delivery owing to fetal distress. Additionally, these patients also had significantly unfavorable pregnancy outcomes.

In the current investigation of the umbilical artery, a total of 41 instances were examined. Among these cases, it was observed that 14 individuals (34.2%) exhibited abnormal umbilical artery Doppler indices, while the remaining 27 cases (65.8%) displayed normal Doppler indices. In the examination of middle cerebral artery Doppler velocimetry within a cohort of 41 individuals, it was shown that 25 participants (60.97%) had aberrant Middle cerebral artery findings. The Doppler results revealed an elevation in diastolic flow with a brain-sparing effect (I) in a majority of instances, specifically 16 cases (39.03%). Additionally, normal Middle cerebral artery Doppler indices were seen in the other cases.

Another study observed similar results. The researchers examined 58 singleton pregnancies that were more than 30 weeks gestation. Doppler was utilized to examine these pregnancies, which were complicated by both IUGR and severe pre-eclampsia. Out of the total sample size, 35 individuals (60.3%) were classified as primipara, whereas 23 individuals (39.7%) were classified as multipara. Out of the whole sample size, 36 individuals (62%) underwent cesarean birth, while 22 individuals (37.8%) had a vaginal delivery. Out of the total study population, 58 patients were included, of which 36 individuals experienced either a significant or minor adverse effect.[14-16]

In the current analysis of 50 patients, 18 had aberrant umbilical artery Doppler indices, whereas 32 had normal Doppler indices. In our investigation of 50 PIH patients, 8 demonstrated reversal of a wave in the Ductus venosus waveform (16%), whereas 42 had a normal Ductus Venosus Doppler waveform (84%). Out of the 18 instances where the uterine artery was deemed to be normal, 11 (61.1%) had birth weights of more than 2,500 grams (normal), and there were no births where the weight of the infant was less than 1,000 grams. Birth weights below 1000 grams occurred in 2 of 15 patients with unilateral uterine artery abnormalities (U). Birth weights between 1500 and 2500 grams were seen in 8 instances (53.33 percent). In their study, Chan et al. (2017) conducted weekly umbilical artery (UA) and middle cerebral artery (MCA) Doppler ultrasound (US) exams on a cohort of 71 high-risk fetuses until delivery. In a subset of 71 fetuses, a total of 15.5% (11 instances) experienced perinatal mortality or significant morbidity. These adverse outcomes included major cerebral hemorrhage, periventricular leukomalacia, necrotizing enterocolitis, and severe neurological impairment.

It is important to note that follow-up data was available for 24 cases, but only up to the age of 2 years. The utilization of the most recent Doppler ultrasound (US) findings for analysis revealed that the ratio of UA/MCA resistance index exhibited greater sensitivity (75% compared to 64%) but lower specificity (60% compared to 74%) when compared to the UA systolic-to-diastolic ratio. The utilization of Doppler ultrasound in the assessment of unfavorable outcomes showed improved predictive capabilities when individual analyses were conducted. In a study, a total of 100 instances of pregnancy-induced hypertension (PIH) occurring between 28 and 36 weeks of gestation were examined over two years. The objective of the study was to investigate the characteristics of the uterine, umbilical, and fetal middle cerebral arteries.[17,18]

CONCLUSION.

Doppler ultrasound can detect cases of pregnancy-induced hypertension at an early stage of gestation through a reliable and non-invasive hemodynamic testing method. The utilization of Doppler indices obtained from fetal circulation has demonstrated a consistent ability to accurately forecast unfavorable perinatal outcomes in obstetric patients belonging to high-risk populations, such as those diagnosed with pregnancy-induced hypertension (PIH). Understanding the uterine and umbilical artery waveform has the potential to enhance pregnancy management and facilitate the early detection and evaluation of pregnancy-induced hypertension, surpassing alternative antepartum testing methods in terms of gestational age.

The process of early identification offers the potential for early intervention and therapeutic measures. The Doppler patterns exhibit a longitudinal pattern, characterized by first alterations in the umbilical artery, followed by changes in the middle cerebral artery and other peripheral arteries. Venous alterations mirror the arterial pattern and manifest in fetuses with significant impairment. The utilization of the Doppler examination is of significant importance in the monitoring of the redistribution of a growth-restricted fetus, perhaps aiding in the determination of the most favorable timing for delivery.

LIMITATIONS.

The limitations of this study include a small sample population who were included in this study.

GENERALIZABILITY.

The findings of this study cannot be generalized for a larger sample population.

RECOMMENDATION.

Low-dose aspirin is recommended in patients with chronic hypertension in pregnancy from between 12- and 28 weeks gestation to delivery.

ACKNOWLEDGEMENT.

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LIST OF ABBREVIATIONS.

PIH- pregnancy-induced hypertension
WHO- World Health Organisation
BMI- Body Mass Index
PP- placental protein
PLGF- placental growth factor
BPD- Bi-parietal diameter
AC- abdominal circumference
FL- Femur length
MGA- Mean gestational age
UV- umbilical vein
IVC- inferior vena cava
MCA- Middle cerebral artery
UA- Umbilical Artery
PIH- perinatal infectious hepatitis
APGAR- Appearance, Pulse, Grimace, Activity, and Respiration
IUGR- Intrauterine growth retardation
US- Ultrasound

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CONFLICT OF INTEREST.

The authors report no conflicts of interest in this work.

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