

**COMPARISON OF DUCTUS VENOSUS DOPPLER
WAVEFORM IN HYPERTENSIVE AND NON-
HYPERTENSIVE PREGNANCIES**



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By

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DEDICATION

This thesis is dedicated to my beloved parents, whose unwavering support and encouragement have been the foundation of my journey. Your sacrifices and belief in my potential have inspired me to strive for excellence.

To my wife, siblings, and my very close friend thank you for your love, laughter, and companionship. Your presence has made this journey more meaningful.

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Thank you all for being my pillars of strength

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LIST OF ABBREVIATIONS

FULL FORM	ABBREVIATION
Socioeconomic Status	SES
Pregnancy Induced Hypertension	PIH
Hypertension	HTN
Amniotic Fluid Index	AFI
Systolic-Diastolic Ratio	SD Ratio
Pulsatility Index	PI
Resistivity Index	RI
Intrauterine Growth Restriction	IUGR
Peak Systolic Velocity	PSV
End-Diastolic Velocity	EDV
Mean Velocity	MV
Ductus Venosus	DV
Gestational Age	GA

ABSTRACT

Introduction: Hypertensive disorders of pregnancy (HDPs), globally affecting about 5-10% of pregnancies, disturb the blood flow in the uterus and placenta, including fetal hemodynamics. This study was carried out to compare ductus venosus (DV) Doppler waveforms-an effective measure of the degree of fetal compromise-in hypertensive and normotensive pregnancies.

Aim: To rule out DV Doppler variations in HDP and assess their clinical utility.

Methodology: The current cross-sectional study involved 110 subjects, all of whom were pregnant women: 55 of them were hypertensive while the other 55 were normotensive and in their second or third trimesters. The assessment would be based on Doppler study of the fetal vessels in the pregnant women. The following parameters of Doppler indices would be analyzed: the Pulsatility index (PI), the resistive index (RI), the systolic-diastolic (S/D) ratio, the end-diastolic velocity (EDV), the peak systolic velocity (PSV), and the mean velocity flow (MV-Flow). The level of significance (p) was to be set at less than 0.05.

Results: In cases of hypertensive pregnancies, there was significantly more vascular resistance as shown by increased S/D ratio (5.39 ± 5.28 vs. 2.34 ± 1.98 ; $p = 0.003$), PI (1.07 ± 0.54 vs. 0.74 ± 0.32 ; $p = 0.001$), and RI (0.66 ± 0.32 vs. 0.53 ± 0.19 ; $p = 0.037$). The reduced flow velocities associated with them were as follows: EDV (6.62 ± 20.02 vs. 15.21 ± 14.03 cm/s; $p = 0.012$), PSV (12.65 ± 35.00 vs. 34.98 ± 24.34 cm/s; $p < 0.001$), and MV-Flow (3.57 ± 18.50 vs. 15.84 ± 12.24 cm/s; $p < 0.001$). These results were also associated with higher incidence of excessive amniotic fluid (49.1% vs. 29.1%, $p = 0.032$). There were no significant differences in gestational age and maternal parity.

Conclusion: Hypertension remarkably elevates blood resistance indices on Doppler and impairs blood flow, which represents placental insufficiency and fetal cardiac stress. Doppler evaluations of the DV serve as an early biomarker of fetal compromise in hypertensive pregnancies, and thus its integration into antenatal surveillance protocols will lead to timely interventions.

Chapter 1

INTRODUCTION

Hypertensive disorders of pregnancy (HDP) remain one of the main contributors to maternal and perinatal death rates worldwide since they affect about 5–10 percent of maternal population [\(01\)](#). The four states of maternal vascular dysfunction that disrupt blood flow to the fetus relate to both chronic hypertension along with gestational hypertension and preeclampsia and eclampsia [\(2\)](#). Preeclampsia develops as superimposed hypertension in women with chronic hypertension due to blood pressure levels exceeding 140/90 mmHg before pregnancy or before 20 weeks of gestation with a risk elevation rate of 20–25% [\(03\)](#). Gestational hypertension begins in the second or third trimester without proteinuria elements yet still raises maternal cardiovascular risk for life [\(04\)](#). Endothelial injury with elevated blood pressure constitutes preeclampsia which triggers 10–15% of premature deliveries and leads to 12% of maternal mortality [\(05\)](#). The medical condition eclampsia causes fatal seizures and organ system collapse and requires immediate maternal delivery because of its very rare occurrence [\(06\)](#).

HDP strongly affects low-resource areas because they lack prenatal medical attention together with insufficient diagnostic tools [\(07\)](#). Long-term effects of HDP result in heart disease for mothers together with various health problems in their offspring which include delayed brain development and metabolic issues. The acquisition of epigenetic characteristics in HDP-exposed fetuses modifies genes related to placental angiogenesis which subsequently raises their risk of developing adult diseases. The requirement for ductus venosus (DV) Doppler as an error prediction tool becomes validated through recent research findings [\(08\)](#).

The ductus venosus represents a unique fetal shunting connection which emerges from the umbilical vein before it reaches the inferior vena cava without passing through the hepatic circulatory system. The DV has a narrow passage with a sphincter by the umbilical vein which provides precise control of blood movement [\(09\)](#). The wall tissue of the ductus venosus contains an exclusive blend of smooth muscle cells and elastic fibers to facilitate fluid dynamic changes for application to blood pressure needs. The development of the DV reaches completion between weeks 5-7 of gestational age to allow better blood flow from the placenta toward the fetal heart and brain. The ductus venosus carries 50 to 60 percent of blood from the

umbilical vein to deliver essential blood flow to vital organs when stress occurs [\(10\)](#). The DV remains open because of three factors including low fetal oxygen levels and prostaglandins (PGE₂) along with nitric oxide that restrain premature contracting. After birth the ductus arteriosus closes but the DV follows suit by closing naturally within days following birth due to blood flow changes and rising oxygen levels in the newborn [\(11\)](#). The placental supply from spiral arteries becomes dysfunctional in HDP pregnancies because of abnormally remodelled arteries which causes reduced blood flow and chronic hypoxic conditions. UV Doppler studies reveal changes in the ductus venosus structure and blood circulation patterns during hypertensive pregnancies through hypoxic conditions. Anatomical modifications provide evidence about how DV acts as an adaptive response to placental inadequacy [\(12\)](#).

Recording DV blood flow using MRI technology demonstrates how velocities rise most near the area where the IVC meets the DV. New evidence through this research shows that DV depicts complicated blood mechanics while reacting to native stress in the uterus [\(13\)](#). Scientific research has shown that the DV stands apart from other fetal shunts by giving priority to cerebral oxygen delivery even during severe placental insufficiency. Representatives from the medical field need to understand these complex anatomical aspects and functional characteristics to interpret findings from Doppler tests in HDP [\(14\)](#).

Hypertensive disorders of pregnancy stem from defective trophoblast invasion and incomplete remodeling of uterine spiral arteries. The trophoblast cells usually penetrate maternal blood vessels thereby creating high flow and low pressure pathways for placental blood circulation [\(15\)](#). HDP leads to insufficient trophoblast penetration during pregnancy which produces restricted blood vessels that create placental oxygen deprivation together with oxidative stress. The hypoxia state of placental tissues upregulates the production of anti-angiogenic factor soluble fms-like tyrosine kinase-1 (sFlt-1). This protein binds to vascular endothelial growth factor (VEGF) and placental growth factor (PlGF) thereby impairing endothelial cellular function. The damage to the vascular lining causes vascular constriction along with proteinuria and abnormal blood clottability which defines preeclampsia [\(16\)](#).

The placental production of ROS during oxidative stress causes DNA damage to mitochondria alongside NLRP3 inflammasome activation [\(17\)](#). The cascade of pro-

inflammatory cytokines including IL-1 β , IL-18 causes further deterioration of maternal vascular function alongside impaired uteroplacental blood flow. The stressed condition of syncytiotrophoblast cells results in the release of EVs which contain microRNA-210 that blocks endothelial nitric oxide synthase (eNOS) in maternal blood vessels leading to diminished vasodilation. These molecular contact points establish a harmful spiral between placental tissue ischemia and systemic inflammation which results in fetal growth restriction or stillbirth [\(18\)](#).

New scientific evidence demonstrates that existing maternal medical conditions intensify the pathophysiological processes of HDP. The body of pregnant women with obesity and diabetes produces higher levels of oxidative stress by causing increased production of placental lipid peroxidation and advanced glycation end-products (AGEs) [\(19\)](#). An abnormal invasion of trophoblast cells results from improper regulation of maternal immune cells such as natural killer cells and regulatory T cells. Investigators explore placental dysfunction reduction by supplementing PlGF and prescribing statins as well as mitochondrial antioxidants for improved fetal wellness [\(20\)](#).

Fetal circulation benefits from significant ductus venosus assistance during situations of placental insufficiency. The DV directs oxygenated blood away from the liver to bypass straight to the heart and brain thus guaranteeing proper blood flow to these organs under hypoxic stress conditions [\(21\)](#). The DV sphincter constriction caused by catecholamines together with nitric oxide results in the adaptation process named "centralization" that helps save cerebral and coronary circulation pathways. The body uses this protective response in acute hypoxic situations yet chronic hypoxemia in HDP causes systemic failure by creating venous congestion and compromising heart function [\(22\)](#).

The DV waveform examined through Doppler studies gives essential information about fetal cardiovascular health. Blood flow that returns from the body toward the heart secretes three pressure waves which align with venous return demands and cardiac requirements [\(23\)](#). Fetal acidemia with accompanying intrauterine demise occurs in 24% of pregnancies among those with severe preeclampsia who display a reversed A-wave Doppler during examination [\(24\)](#). High placental resistance in HDP creates increased fetal cardiac afterload that reduces ventricular compliance thus impairing diastolic filling which results in higher pulsatility index (PI) in the DV [\(25\)](#).

Research shows that Doppler observations of the ductus venosus provide better prediction of neural developmental complications compared to other Doppler findings including umbilical artery resistance index. The DV's ability to forecast patient outcomes serves as an essential tool for determining when to deliver a baby and creating neonatal care strategies [\(26\)](#).

The non-invasive examination method of Doppler ultrasonography uses the ductus venous flow for evaluating fetal blood movement patterns to understand placental health and cardiac activity. This medical technique determines blood flow velocity and resistance indices which include pulsatility index (PI) and peak velocity index for veins (PVIV) to evaluate venous return and cardiac preload [\(27\)](#). Normal fetal heart activity shows the DV waveform features forward blood movement through all phases of the cardiac cycle and its peak movement surpasses 25% of its lowest point movement. The detection of missing or mirrored A-wave signals indicates poor atrial filling together with increased central venous pressure [\(28\)](#).

Clinical staff combine DV Doppler data with umbilical artery (UA) and middle cerebral artery (MCA) assessments to classify fetal safety levels. A reduction in middle cerebral artery resistance serves as the first sign of deep vein abnormalities in hypoxic pregnancies because it represents fetal brain compensation for hypoxic conditions [\(29\)](#). When obtaining Doppler velocity measurements accuracy depends heavily on qualified operators who follow standardized imaging angles because fetal movement together with maternal body shape can produce unreliable results [\(30\)](#). A study combined the results of 3D/4D Doppler with artificial intelligence (AI)-based analytics to enhance accuracy in clinical practice yet its usage in low-resource localities remains restricted [\(31\)](#). Serial doppler velocity measurements of the duodenal artery according to international society of ultrasound in obstetrics and gynecology (isuog) guidelines must be performed in high-risk pregnant women starting after week 26 [\(32\)](#). Doctors use abnormal ultrasound results to determine when interventions like antenatal corticosteroids for lung maturation will be beneficial alongside magnesium sulfate for neuroprotection. Discussions continue regarding both the best frequency of monitoring and the delivery criteria especially in cases of early-onset preeclampsia when DV waveforms remain normal [\(33\)](#).

The conditions of HDP result in elevated placental vascular resistance which increases the fetal cardiac work and produces notable changes in DV hemodynamics. The most important DV waveform issue is a reverse in the A-wave

during atrial contraction since it reveals high right atrial pressure together with poor ventricular compliance (34). Progressive placental dysfunction can change the waveform pattern to show diastolic dysfunction symptoms which present as monophasic or biphasic results (35).

Multiple studies following subjects in time show how HV conditions affect maternal heart development throughout pregnancy. Research established that advanced fetal arrhythmias lead to three-day emergencies which require rapid infant birth as a means to avert fetal demise. Nonetheless pregnancies with constant normal Doppler waveforms during severe maternal hypertension tend to have favorable neonatal results due to efficient serial monitoring (36). Some fetuses with regular DV waveforms suffer preterm birth because of placental abruption or maternal organ failure which demonstrates the necessity of conducting multi-faceted monitoring (37).

Studies reveal that pravastatin combined with recombinant PlGF treatment shows potential to enhance placental circulation and DV blood flow. The research showed that pravastatin therapy decreased sFlt-1 levels together with restoring normal Pi measurements of the ductus venosus in preeclamptic pregnancies (38). Maternal use of oxygen therapy for fetal hypoxia relief continues to be investigated despite limited evidence regarding its effects on Doppler waveforms. The DV proves valuable as a biomarker to evaluate treatment effectiveness and individualize obstetric medical care (39).

Although, there are some deficiencies in current knowledge in the field of HDP and fetal circulation. Especially, the relation between maternal hypertension and abnormal waveform of the ductus venosus, the exact pathways, are somewhat unknown. In addition, their clinical usefulness as biomarkers for the onset of unfavorable outcomes in hypertensive gravidas deserves exploration. In studying these relationships, clinicians can learn how maternal hypertensive disorders affect fetal health, to properly channel necessary ways of approach to enhance desirable pregnancy outcomes.

This study aims to systematically review, analyze and compare ductus venosus Doppler waveforms in hypertensive and non-hypertensive pregnancies. The study aims to describe the pathophysiological relationship between maternal hypertension, placental dysfunction and fetal cardiovascular changes by associating them with the clinical outcomes. This could lead to better intervention possibilities in all phases of

the pregnancy, thus more careful fetal surveillance and management plan for pregnancies described as high risk.

AIM AND OBJECTIVES

- To compare ductus venosus Doppler waveform patterns in hypertensive and non-hypertensive pregnancies.
- To identify early signs of fetal compromise in hypertensive pregnancies.

Chapter 2

LITERATURE REVIEW

Salman AM, et al. (2021) conducted a study that Hypertension in pregnancy, especially when accompanied by preeclampsia, poses significant risks to both the mother and baby. Ultrasound scans using color Doppler have been used to monitor fetal health in these cases. This study investigated the effectiveness of Doppler scans in predicting adverse outcomes in pregnant women with hypertension during their third trimester. From July 2018 to July 2019, 50 hypertensive pregnant women were enrolled in a follow-up study at a medical facility in Baghdad, Iraq. Pregnancy outcomes were considered poor if the fetus died during prenatal care or if the newborn experienced more than two of the specified complications. The flow in the umbilical artery and the patterns observed in the Ductus Venosus are similar. Additionally, the measures of the middle cerebral artery and umbilical artery for expectant mothers with hypertension can accurately predict the health outcomes of their newborns (40).

Malhan P, et al. (2020) conducted a study that Antenatal ultrasound (USG) helps doctors find pregnant women who may have problems like high blood pressure during pregnancy (PIH) and preeclampsia. This study aimed to use Doppler ultrasound to measure blood flow in the uterus, umbilical cord, and fetal brain (MCA) in women with PIH and see if these measurements could predict how the baby would do after birth. Over time, 50 pregnant women diagnosed with PIH were given USG and color Doppler tests, and their babies were monitored for any problems up to 7 days after birth. USG was done using a probe with a frequency of 1-5 MHz. About 46% of the women were between 26 and 30 years old, and 64% had had children before. During pregnancy-induced hypertension (PIH), changes in Doppler readings of blood flow in certain arteries are linked to increased risk for fetal compromise. Altered readings in the umbilical artery (42 patients), uterine artery (26 patients), and fetal middle cerebral artery (9 patients) were noted. Critical findings included absent or reversed blood flow during end-diastole in the umbilical artery, persistent "notch" in the uterine artery, and a protective effect on the fetal brain (brain-sparing effect). These abnormal readings often appeared in multiple

arteries in cases of fetal death or severe neonatal complications. Doppler scans can detect these changes early, allowing for close fetal monitoring and timely intervention to prevent or manage complications (41).

Madhu P. (2020) conducted a study aims to: 1. Investigate Doppler values in the umbilical artery, middle cerebral artery, and uterine artery through Doppler ultrasound in pregnant women with PIH. 2. Determine the effectiveness of Doppler ultrasound in forecasting birth outcomes in women with pre-eclampsia. 3. Evaluate the role of Doppler ultrasound in handling pregnancy-induced hypertension. This prospective study includes at least 150 patients diagnosed with PIH who were referred to the Radiology Diagnostics at Mysore Medical College and Research Institute over 18 months. All subjects will be examined by Doppler sonography and will be followed until delivery and the postpartum period. The patient was informed about the gentle and pain-free nature of the ultrasound exam. A gel was spread on their abdomen to ensure a clear signal. The ultrasound machine used was the Philips Affinity 70 Colour Doppler, which has a curved transducer with a frequency range of 3-5 MHz. The blood vessels were first located using a real-time scanner, and then a special pulsed Doppler mode was used to record the blood flow. The highest Doppler shift frequencies were measured, and calculations were made based on the results. The exam was performed while the fetus was not breathing to minimize any interference with the Doppler signals. The study involved 150 women diagnosed with pregnancy-induced hypertension (PIH). Among these cases, 58 were severe pre-eclampsia (PE) and 33 were intrauterine growth restriction (IUGR). The patient's age ranged from 18-36 years, with most (41%) being first-time pregnancies (primigravida) and fewer (39%) being second or later pregnancies (multigravida). The mean gestational age was 22.8 years, and most patients (62) were between 35-36 weeks. Doppler waveform analysis of umbilical arteries, uterine arteries, and middle cerebral arteries (MCA) was performed for all patients. Results showed that 34 patients had an increased systolic/diastolic (S/D) ratio, 21 had an raised resistance index (RI), and 31 had an elevated pulsatility index (PI). The peak perinatal mortality rate (31%) was observed in the increased RI group compared to the other groups (42).

Mishra R, et al. (2020) conducted a study on Pregnancy induced hypertension (PIH) is associated with adverse perinatal outcome. Multi vessel color Doppler studies are

useful in these scenarios for timely intervention. The aim of present study was to establish the clinical importance of umbilical, middle cerebral and uterine artery Doppler in pre-eclampsia and to assess their role in predicting perinatal outcome. The study includes 150 pregnant females with PIH. These patients were assessed with colour Doppler and monitored for any adverse perinatal outcome. Out of 150 cases: Most happenings (70%) occurred in women aged 20-30. Atypical Doppler readings in the uterine artery were present in 98 cases (65.3%), and normal readings in 52 cases (34.3%). Deviant Doppler readings in the middle cerebral artery were present in 94 cases (64.6%). Anomalous Doppler readings in the umbilical artery were present in 53 cases (35.4%), and normal readings in 97 cases (64.6%). Reverse flow in the ductus venosus waveform was observed in 27 cases (18%). Five cases (3.3%) resulted in perinatal mortality. This study suggests that monitoring Doppler parameters can aid in early detection of preeclampsia (PIH) and improve pregnancy outcomes, compared to other prenatal testing methods (43).

Loardi C, et al. (2021) conducted a study to determine how well uterine artery (UtA) Doppler scans can predict pregnancy outcomes in women with high blood pressure during pregnancy. The study will look at pregnancies from 2011 to 2017 where the mother was diagnosed with high blood pressure and had a UtA Doppler scan when they were admitted to the hospital. The study participants will be divided into groups based on whether or not they had preeclampsia (PE) and whether or not their UtA Doppler scan was abnormal (a mean pulsatility index above the 95th percentile). The study will examine the pregnancy outcomes, including any complications for the mother or baby, the length of the pregnancy from admission to delivery, and how well the UtA Doppler scan predicted these outcomes compared to the standard definition of PE. The study involved 311 mother-infant pairs, the effectiveness of two classifications in predicting maternal and neonatal complications was analyzed. The ISSHP definition was better at identifying mothers at risk for adverse pregnancy outcomes compared to UtA Doppler, with a higher relative positive likelihood ratio (1.50 vs. 1.31). Conversely, UtA Doppler was more accurate in predicting adverse outcomes for infants compared to the PE definition (2.21 vs. 1.61). Additionally, UtA Doppler was linked to earlier gestational ages for delivery in both women with preeclampsia (PE) and those with hypertensive disorders of pregnancy (HDP) without superimposed PE ($p = 0.009$ and $p = 0.037$, respectively). These findings

suggest that UtA Doppler at HDP diagnosis is a valuable tool in assessing both maternal and neonatal risks (44).

Chavda AR, et al. (2020) conducted a study on Gestational hypertension is a common complication in pregnancy. To improve birth outcomes, it's crucial to identify women at risk early on. Doppler ultrasound can aid in identifying these women and monitoring their pregnancies. This study evaluated the usefulness of Doppler ultrasound in assessing blood flow velocity in women with gestational hypertension. The study's goal was to determine if Doppler indices could predict perinatal outcomes such as premature birth, low birth weight, or other pregnancy complications. A 12-month study examined the effectiveness of color Doppler ultrasound in 50 pregnant females marked with gestational hypertension in the end of 7th month of pregnancy. The first scan was done after diagnosis. The study assessed the flow of blood in umbilical, uterine, and fetal middle cerebral arteries using Doppler ultrasound. About 76% of the participants were between 20 and 30 years old. Abnormal umbilical artery Doppler was found in 58%, while normal umbilical artery Doppler was found in 42%. 23 subjects had a cerebro-placental index of 1. The study suggests that Doppler ultrasound can accurately predict potential adverse fetal outcomes in women with gestational hypertension (45).

Damle N, et al. (2020) conducted a study on Pregnancy-induced hypertension is a well-known medical abnormality that can occur during pregnancy. The current study aimed to underline the significance of Doppler scans in pregnancy-induced hypertension, correlate with the perinatal results, and provide improved prevention, early detection, and management strategies. Methods: 138 patients with PIH at or after 28 weeks of gestation were included in the study. Routine Doppler studies were conducted, only the most recent Doppler scan values within a week of delivery were used for analysis. Patients were monitored until delivery. After that, the prenatal and maternal outcomes were examined. Doppler results for the umbilical artery (UA) showed that 26.8% had an aberrant S/D ratio, 31.1% had an abnormal Recoiling Index (RI), and 2.90% had an abnormal Pulsatility Index (PI). However, compared to aberrant umbilical S/D artery ratio (66.7%) and umbilical artery RI ratio (66.7%), perinatal mortality was highest (100%) in the anomalous umbilical artery PI group overall. The umbilical artery S/D ratio had a 73.91% predictive accuracy in

predicting an abnormal perinatal outcome, compared to a 68.12% estimated by the UA RI ratio and a 61.59% predicted by the UA PI. It was discovered that the umbilical artery PI had a well specificity than the UA S/D ratio and UA RI for predicting an unfavorable perinatal outcome. The highest perinatal mortality was noted in aberrant MCA S/D ratio, followed by deviant MCA PI, according to fetal middle cerebral artery Doppler indices, which showed abnormal MCA S/D ratio, RI, and PI. Cerebroplacental ratio (MCA PI/UA PI) was the most accurate predictor of a poor perinatal outcome (97.65%). When it comes to forecasting a poor perinatal outcome, the cerebroplacental index has the best precision, as compared to the umbilical artery pulsatility indices and the MCA Pulsatility index in this study. In order to identify affected babies in utero and promptly take appropriate treatment, the current study highlighted the need of Doppler ultrasonography examinations in PIH patients. Compared to Umbilical artery RI and PI, the umbilical artery S/D ratio had a high predictive accuracy for predicting worse neonatal outcomes. Furthermore, when compared to other Doppler measures, the umbilical artery PI exhibited the best specificity. Significant perinatal outcomes were linked to both the absence of end diastolic flow and its reversal (46).

Karena ZV, et al. (2022) carried out a Feto-maternal circulation is evaluated by Doppler imaging of the uterine and fetal arteries. Fetal injury and placental malfunction are indicated by an abnormal Doppler scan. This study is to investigate the association between perinatal outcomes in both normal and high-risk pregnancies and the Doppler velocimetry of the middle cerebral artery, umbilical artery, and uterine artery. In a tertiary healthcare facility, a prospective cohort research was carried out. 150 individuals in two groups, 75 in the high-risk cohort and 75 in the non-high-risk cohort, were all 1835 years of age and had gestational ages ranging from 28 to 40 weeks. The high-risk cohort consisted of pregnant women with intrauterine growth restriction, gestational hypertension, preeclampsia, preeclampsia, and IUGR. We examined Doppler parameters and their relationship to perinatal outcomes. In comparison to the MCA Doppler and CPR measures, the responses of the umbilical artery index were strong predictor of poor infant outcomes. Doppler monitoring of the babies for well-being throughout the third trimester of high-risk pregnancies complicated by pregnancy-induced hypertension, preeclampsia, and IUGR improves the perinatal outcome and facilitates prompt

intervention (47).

Rajput DK, et al. (2022) Prenatal care is primarily intended to take out females who may be at risk for issues, such as pre-eclampsia, due to compromised uteroplacental circulation. Examine the perinatal outcome in pregnancies with modified Doppler indices and explain the practical use of Doppler ultrasonography in obstetrics with measurement of blood flow velocity waveform in pre-eclampsia. 40 pregnant females with PIH who were examined sonographically using color Doppler are the subjects of this prospective research, which will be monitored for any unfavorable perinatal outcomes. Forty-five percent of the 40 cases were in the 25–29 age range. In our study, 26 patients (65%) had a normal Doppler index, while 14 instances (35%), had deviant umbilical artery Doppler indices. Six instances (15%) of perinatal death were observed in this investigation. Understanding the Doppler artery waveform may aid to enhance pregnancy outcomes and allow for the early detection and evaluation of pre-eclampsia (48).

Demirören T, et al. (2023) researched out that Doppler ultrasonography spectrum analysis is a non-invasive method of evaluating uteroplacental (S/D ratio) and fetal circulation alterations (PI value). In order to detect perinatal morbidity and mortality in hypertensive pregnancies, the current study sought to show how Doppler ultrasonography should be used in conjunction with traditional well-being examinations. Between April 1992 and May 1994, 88 pregnant women with a diagnosis of high-risk pregnancy and hypertension participated in this prospective study. Every case underwent a non-stress test (NST), and after a non-reactive NST, fetal agony was assessed using a biophysical profile (BP) and/or a contraction stress test (CST). In the group with normal uterine and umbilical artery Doppler tests, there were no cases of perinatal mortality, antepartum and intrapartum fetal discomfort, newborn SOB, or oligohydramnios. One instance, diagnosed with antepartum fetal distress, was delivered via preterm cesarean section and had just umbilical artery Doppler flow pathology. This group did not have any cases of oligohydramnios. It showed an increased perinatal mortality (9.1%) among individuals with pathological uterine artery Doppler and normal umbilical artery Doppler. In general, it is reasonable to use Doppler ultrasonography to detect any anomalies in hypertensive pregnant women throughout the early stages of pregnancy

and to follow up with traditional fetal antepartum monitoring tests relevant to their umbilical artery Doppler pathologies at suitable intervals (49).

Duragkar S, et al. (2023) Pregnancy-related hypertensive disorders (HDP) provide serious health hazards to both the mother and the fetus. Research on the effectiveness of Doppler indices in forecasting unfavorable fetal outcomes in HDP patients is still ongoing. The purpose of this observational study was to evaluate the relationship between poor fetal outcomes in HDP patients and aberrant uterine artery Doppler indices. We recruited 138 pregnant women with HDP who were older than 28 weeks gestation and singleton pregnancies during a two-year period. Doppler examinations of the uterine artery, laboratory tests, and comprehensive clinical evaluations were carried out. The systolic/diastolic (S/D) ratio, resistance index (RI), and pulsatility index (PI) were among the Doppler indicators evaluated. APGAR (appearance, pulse, grimace, activity, and respiration) ratings, birth weight, NICU hospitalizations, and perinatal fatalities were used to categorize adverse fetal outcome. To assess the prognostic usefulness of Doppler indicators, statistical studies were conducted. Unfavorable fetal outcomes were positively correlated with abnormal uterine artery Doppler indices, particularly an increased S/D ratio and the presence of a diastolic notch. However, among HDP patients, there was no discernible link between poor fetal outcomes and Doppler indices like PI and RI. These results imply that in HDP patients, the S/D ratio and the existence of a diastolic notch in uterine artery Doppler tests may serve as prognostic indicators for unfavorable fetal outcomes. In patients with hypertensive disorders of pregnancy, uterine artery Doppler indices—more especially, the S/D ratio and the existence of a diastolic notch—seem to be useful indicators of unfavorable fetal outcomes. These results highlight how crucial routine uterine artery Doppler flow monitoring is for managing HDP and identifying pregnancies at increased risk for unfavorable fetal outcomes (50).

Bucher V, et al. (2024) conducted a study on One of the main causes of maternal and perinatal morbidity and death during pregnancy is hypertensive disorders. Early identification of women at high risk for problems would allow for triage of treatment, appropriate allocation of scarce resources, and implementation of focused measures to avoid difficulties. We added single outcomes and revised a meta-

analysis and systematic review. Pregnant women with hypertension problems were included. Tests that predicted worse maternal and/or perinatal outcomes were exposures. From January 2016 to February 2024, we conducted searches on Medline, Embase, CINAHL, and the Cochrane Library. Studies found in the prior evaluation were included. Effect measurements were computed. Area under the receiver-operating-characteristic curve (AUROC) was pooled for comparable predictive testing and results. Eighty of the 2898 studies that were found were included. There were 110 included studies with 506,178 women after 30 were added from the prior evaluation. The majority of results could not be aggregated because of differences in demographics, tests, and outcome criteria, even though over 1500 tests were conducted. Only studies that reported on the Pre-eclampsia Integrated Estimate of RiSk (fullPIERS) model were eligible to be pooled for maternal outcomes. The AUROC for the 48-hour composite result was 0.78 (95% CI 0.71–0.86, N = 8). Significant heterogeneity was present ($I^2 = 95.7\%$). Data on perinatal outcomes were combined for the soluble FMS-like tyrosine kinase-1 (sFlt-1)/placental growth factor (PlGF) ratio and the pulsatility index in the umbilical artery. Although they were not externally verified, biomarkers such as the sFlt-1/PlGF ratio demonstrated encouraging predictive performance for some outcomes. We were only able to pool a small number of individual perinatal outcomes and no single maternal outcomes, even though we included more than 100 papers with over 1500 variables. External validation of the fullPIERS model revealed modest accuracy, which varied among research and needs be confirmed in every new population. Although promising, angiogenesis biomarkers require confirmation. Standardized outcome measurements and the validation of promising tests should be used in future research (51).

Duncan JR, et al. (2025) suggested that abnormal uterine artery Doppler (UtAD) screens performed in early pregnancy may show poorer pregnancy outcomes; however, little correlation exists between adverse third-trimester pregnancy outcomes and those earlier screens. We will investigate how well they correlate with third-trimester outcomes. These included preeclampsia, small babies for gestational age, prematurity, and perinatal mortality, among other perinatal morbidities such as cesarean section for fetal distress, low pH in umbilical arteries, low 5-minutes Apgar scores, and intensive care unit (ICU) admission in the lowest Apgar scores,

particularly in SGA-born infants. Adding maternal characteristics and biochemical markers to the prediction models would increase their capability to predict UtAD abnormalities, with the evaluation being more accurate when it is conducted closer to the diagnosis or delivery. As per this study, UtAD's predictive precision for unfavorable pregnancy outcomes in the third trimester is most accurate. The prediction performance of the UtAD combination models may be improved by serial evaluations as opposed to a single third trimester assessment (52).

Berhe AK, et al. (2020) conducted a cohort study In Ethiopia, the prevalence of pregnancy-induced hypertension varies between 2.2 and 18.3%. However, in Ethiopia's Tigray regional state, nothing is now known regarding the harmful perinatal effects of pregnancy-induced hypertension. Goal was to assess the pattern how hypertension developed by pregnancy caused unfavorable perinatal outcomes. 782 pregnant women who were receiving prenatal treatment in hospitals in the were the subjects of a prospective cohort study. Normal females were in a control group, and pregnant females with Pre-eclampsia were marked as an exposed group. Women around 28 and 35 weeks of gestation who have been diagnosed with preeclampsia, eclampsia, and gestational hypertension are the focus of this study. Relative risk was examined using a modified Poisson regression model with robust standard errors. According to this study, women with pregnancy-induced hypertension had a greater overall incidence of unfavorable perinatal outcomes than women with normotension (66.4% vs. 22.2%). When confounders were considered, babies born to women with pregnancy-induced hypertension had a higher risk of low birth weight, birth asphyxia, small for gestational age, preterm delivery, stillbirth, admission to the neonatal intensive care unit, and perinatal death than pregnant women with normotension. In Ethiopia's Tigray regional state, women with pregnancy-induced hypertension had higher rates of unfavorable perinatal outcomes. Therefore, to lessen the negative perinatal effects of pregnancy-induced hypertension, healthcare professionals should prioritize prevention, early diagnosis, and timely therapy (53).

Li F, et al (2021) studied that Studies evaluating the relationship between hypertensive disorders during pregnancy (HDP) and adverse pregnancy outcomes (APOs) in children are currently lacking a comprehensive review and yielding conflicting results. To examine and summarize the relationship between HDP and

child risk for APOs, we conducted a meta-analysis of cohort studies. To find relevant studies, searches were conducted until May 2019 throughout the Chinese, Web of Science, Embase, and PubMed databases. To determine the overall combined risk estimates, either a fixed-effects model or a random-effects model was employed. Potential heterogeneity moderators were analyzed. For analysis, 152 cohort studies comprised 36,374,542 women without HDP and 1,426,742 mothers with HDP. In general, the risk of perinatal death, fetal death, stillbirth, neonatal death, congenital malformations, IUGR, LBW, PTB and VPTB (OR = 3.26) in offspring was significantly higher for mothers with HDP than for those without HDP. Subgroup analyses revealed relevant mediators of heterogeneity. Consistent findings came from the sensitivity analysis. There was no indication that the publication was biased. Based on the current research, HDP considerably raises the risk of APOs. To reduce the risk of APOs linked to HDP, more study is required to investigate effective management techniques (54).

Konwar R, et al (2021) carried out a study aiming to quantify how Doppler waveforms relate to perinatal outcomes and pregnancy-induced hypertension (PIH). We looked at the UmA, Middle Cerebral Artery, and UtA Doppler waveforms of 50 pregnant women with PIH whose gestational age (GA) was between 30 and 40 weeks. Using the necessary statistical tests, the relationship between the several Doppler indices, S/D ratio and the perinatal outcomes was assessed. A threshold value of p-value <0.05 was considered significant. The data was analyzed using MedCalc software (MedCalc Software Ltd, Ostend, Belgium) and the Statistical Package for the Social Sciences (SPSS) version-16 (SPSS Inc, Chicago, USA). Of the instances assigned to the 26–30 age range, half (50%) occurred between 38 and 40 weeks of pregnancy. Of the 50 patients, 74% had severe PIH and 68% were primigravida. Patients with mild and severe PIH had substantially different mean UmA PI, mean MCA PI, mean MCA RI, and mean Cerebro Placental Ratio (CPR) (p-value<0.05). 33 (66%) of the patients had unfavorable perinatal outcomes. Poor pregnancy outcomes were substantially associated with deviant UmA & MCA RI, MCA PI, and MCA S/D (p-value <0.05). More negative outcomes were noted in PIH patients with aberrant PI CPR (p-value <0.001), early diastolic notch of UtA. When it came to detecting unfavorable perinatal outcomes, MCA-Pulsatility index and the show up of an early diastolic notch of UtA were the most specific, whereas

CPR showed the highest sensitivity (84.8%). A useful predictor of poor perinatal outcomes in PIH is CPR-PI. Multiple vascular Doppler tests may be useful in managing high-risk pregnancies since they can provide important details about the fetus that is susceptible to hypoxia and placental insufficiency (55).

Al Khalaf SY, et al. (2021) conducted a study on Unfavorable pregnancy outcomes are linked to maternal prolonged hypertension. Prior research looked at the relationship between adverse pregnancy outcomes and either persistent hypertension or antihypertensive medication. Our goal was to compile the data about the impact of antihypertensive medication and persistent hypertension on unfavorable pregnancy outcomes. Web of Science, EMBASE, and Medline/PubMed were searched; observational studies were included, and, when feasible, the impact of race and ethnicity was evaluated in accordance with a documented protocol. Random-effects meta-analyses was used. In all, 81 studies on persistent hypertension and 16 studies on antihypertensive medication were found. The odds of preeclampsia, cesarean section, maternal mortality, preterm birth, stillbirth, and small for gestational age (SGA) were all linked to chronic hypertension. Subgroup studies showed that the observed correlations are unaffected by maternal race or ethnicity. The chances of SGA were greater for women with chronic hypertension using antihypertensive medication (aOR, 1.86; 95% CI, 1.38–2.50) as opposed to those who were not receiving therapy. Negative pregnancy outcomes are linked to chronic hypertension, and these links seem to be unaffected by the race or ethnicity of the mother. Despite the small number of studies, women with chronic hypertension who were receiving therapy were more likely to develop SGA. Because severe hypertension during pregnancy is a risk factor for SGA and women with severe hypertension are more likely to get therapy, this might be the consequence of a direct effect of the medication. Large randomized controlled studies are required to further investigate the impact of antihypertensive therapy on SGA (56).

Baig JA, et al. (2020) to ascertain the perinatal and maternal outcomes in moms with hypertension caused by pregnancy. From January to December 2018, a prospective comparative research was carried out at the Obstetrics and Gynecology department of the Combined Military Hospital Sialkot. In addition to enrolling 200

normotensive prenatal women who maintained their norm-tension until 12 weeks postpartum, the study group also included data from 200 women who developed PIH after 20 weeks of pregnancy. Their demographic info, birth method, and prenatal and maternal outcomes were documented. During the research period, the incidence of pregnancy-induced hypertension was 7.7% out of 2599 births. 52 (26%) of the women with normotension had a cesarean section, while 106 (53%) of the women with pregnancy-induced hypertension had one. There were 17 (8.5%) cases of eclampsia, 69 (34.5%) cases of preeclampsia, and 114 (57%) cases of gestational hypertension. 48 (24%) of the study group's patients needed intensive care hospitalization, compared to 6 (3%) of the control group. In the study group, the maternal death rate was 1.5%. In the research group, there were 30 (15%) prenatal deaths, 66 (35.11%) preterm births, 62 (32.98%) low birth weight neonates, and 84 (44.68%) neonates in need of neonatal intensive care. Pregnancy induced high blood pressure not only increases the number of operative deliveries but also involves high risk of adverse maternal and perinatal outcome (57).

Qiang Y, et al. (2025) conducted a study on The most common pregnancy problem in both high- and low-middle-income nations is hypertensive disorders of pregnancy (HDP). In 2021, low-middle-income countries' age-standardized incidence rate and absolute incidence number of HDP are two and four times greater, respectively, than those of high-income nations. However, between 1990 and 2021, low-middle income countries had a roughly five-fold quicker decline in the age-standardized prevalence rate (-41.1% vs. -8.7%) and incidence rate (-40.8% vs. -7.1%) of HDP than high-income nations. Furthermore, in both high- and low-middle-income nations, HDP is substantially linked to a higher risk of unfavorable perinatal outcomes, such as preterm birth, low birth weight, and perinatal death. We have emphasized HDP's incidence, prevalence, and temporal trend in the current review and its relation with terrible perinatal outcomes in high and low-middle-income countries (58).

El-Demiry NM, et al. (2020) To assess the diagnostic efficacy of Doppler sonography of the umbilical vein (UV), ductus venosus (DV), fetal middle cerebral artery (MCA), and umbilical artery (UA) in order to predict unfavorable perinatal outcomes. 60 women with severe preeclampsia were the subjects of a prospective cohort research that split them into two groups according to unfavorable perinatal

outcomes. Differences that were statistically significant were shown. UA PI ($P < 0.001$), UA RI ($P < 0.001$), MCA PI ($P < 0.005$), MCA RI ($P < 0.001$), Cerebroplacental ratio ($P < 0.001$), DV PSV ($P = 0.004$), and abnormal DV a wave ($P = 0.004$) in ladies with negative and normal perinatal results. For the identification of unfavorable prenatal outcomes, UA RI had the best sensitivity and UA PI and CPR the highest specificity. $CPR < 1$ can be used as a marker to tag fetuses at verge of mortality and morbidity among this type of cases (59).

Moawad EM, et al. (2022) conducted a study With significant maternal and neonatal morbidity and death, preeclampsia is a serious health issue. The goal of this study was to determine that fetal Doppler could accurately diagnose severe late-onset preeclampsia (LOP) and predict unfavorable outcomes. Childbearing women with severe LOP and matched controls participated in a prospective research. Doppler indices were assessed in the umbilical artery (UA) and middle cerebral artery (MCA). The case group's UA indicators were all considerably higher than the controls' ($p < 0.001$). Apart from cord pH state, UA PI and RI were substantially connected with all newborn unfavorable outcomes ($p < 0.05$). Intrauterine growth retardation (IUGR), low 5-minute Apgar score, and newborn intensive care unit admission were all positively connected with abnormal CPR, which was the most sensitive indicator (79, 72.8, and 73.3%, respectively). The most precise method for predicting IUGR in the same environment was abnormal UA PI and RI. The greatest method for predicting unfavorable delivery outcomes in cases of severe LOP is CPR, whereas UA Doppler is still the best indication for such outcomes (60).

Chapter 3

METHODOLOGY

3.1 Research Design: Cross-Sectional Analytical Study.

3.2 Clinical Setting: Data was collected from Gillani Ultrasound Clinic Lahore.

3.3 Sample size:

At least 60 samples were supposed to be selected from both groups, 30 from each group, considering the study's level of significance as 95% and precision level 99%.

$$n = \frac{(Z_{1-\alpha/2}^2 + Z_{1-\beta}^2)(P_1(1 - P_1) + P_2(1 - P_2))}{(P_1 - P_2)^2}$$

$Z_{1-\alpha}$	Confidence Interval	95%
ε	Margin of Error	1%
P_1	Expected proportion of Anomalies in Pedas with Hypertensive Mother	56% (Salman et al., 2021)
P_2	Expected proportion of Anomalies in Pedas with normal Mother	13% (Wu et al., 2025)

An Expected sample size in a group
29≈30

For precision and better statistical computation the sample size was increased to 110 samples (55 in each group)

3.4 Sampling Technique: Convenient sampling technique.

3.5 Study Duration: 09 Months.

3.6 Selection Criteria

3.6.1 Inclusion Criteria:

- All the patients of 2nd and 3rd trimester with normal pregnancies.
- Age groups between 20-40.
- All hypertensive and non- hypertensive female.

3.6.2 Exclusion Criteria:

- Multiple pregnancy.
- Patients with any disease like hypertension and any other disease.

Equipment: Toshiba Xario 45, convex probe 3-5 MHz

3.7 ETHICAL CONSIDERATIONS

The guidelines established by the ethical committee of Superior University, Lahore were taken as a model while pursuing the research and the confidentiality of the research subjects was respected.

- All participants were asked for their written informed permission, which is attached.
- Our top concern was the patient's privacy.
- Before exposing the patient, we got her consent.
- The data collected and information was held confidential.
- Throughout the research, subject's anonymity was maintained.
- The candidates were made aware that there were no harm or disadvantages to the study's methodology.
- They were also given awareness that they can leave the research at any moment, and we took all reasonable precautions to preserve their privacy. No publication that came out of this study will reveal identity.
- Your participation in this research work was optional. You own the freedom to decline participation and to revoke your permission at any time. If you choose not to be a part of this study or withdraw, you won't face any consequences

3.8 DATA COLLECTION PROCEDURE

Data collection was started after the approval of synopsis from the research ethical committee of university. Data was collected according to data collection sheet which was designed after discussion with field experts and reviewing previous literature. The reliability was checked through pilot study and statistical reliability through Cronbach alpha test. Informed permission form was taken from all the subjects.

Scanning Technique:

The patient was positioned comfortably on an examination table, typically in a supine or left lateral position. A specialized Doppler ultrasound probe was used on maternal abdomen in the region where the ductus venosus was visualized, usually around the umbilical cord insertion site. The ultrasound machine was switched to the Doppler mode, allowing for the visualization and assessment of blood flow within the ductus venosus. The angle of insonation was adjusted to ensure an optimal alignment between the ultrasound beam and the direction of blood flow within the ductus venosus. This angle correction of crucial for accurate velocity measurements. Blood flow velocity measurements were taken. The Doppler waveform obtained was displayed on the ultrasound monitor. Parameters such as peak systolic velocity, end-diastolic velocity, pulsatility index (PI), resistance index (RI), and the presence or absence of specific waveforms (e.g., A-wave, S-wave, or absent/reversed A-wave) were evaluated and analyzed.

3.9 DATA ANALYSIS PROCEDURE

- SPSS software version 29 was used to enter and evaluate all the data.
- Descriptive analysis was performed to investigate the distribution of data.
- For quantitative variables, the mean and standard deviation was calculated.
- For categorical variables, percentages and frequencies were computed.
- To compare Doppler indices, a test was used, and a hypertension p-value of less than 0.05 was deemed significant.

Chapter 4

RESULTS

The study included 110 pregnant women, evenly divided between hypertensive (n=55) and non-hypertensive (n=55) groups. The overall mean age was 29.61 ± 4.87 years, with hypertensive women being significantly older (32.07 ± 4.02 years) than non-hypertensive women (27.15 ± 4.40 years; $p < 0.001$). Socioeconomic status distribution was similar across groups: 20% lower class, 70% middle class, and 10% upper class in both cohorts, showing no association with hypertension status ($p=0.949$).

The analysis Within-group comparisons revealed no significant associations between hypertension and either socioeconomic status or parity. Parity distribution was comparable: 17.3% primiparous (1 child), 40.9% with 2 children, 24.5% with 3 children, and 17.3% with 4 children across both groups ($p=0.444$). However, amniotic fluid index (AFI) differed significantly: hypertensive women had higher rates of excessive AFI (49.1% vs. 29.1%) and lower adequate AFI (50.9% vs. 70.9%) compared to non-hypertensive women ($p=0.032$).

The analyses Between-group showed hypertensive women had significantly higher systolic-diastolic ratios (5.39 ± 5.28 vs. 2.34 ± 1.98 ; $p=0.003$) and abnormal Doppler indices, including elevated pulsatility index (PI: 1.07 ± 0.54 vs. 0.74 ± 0.32 ; $p=0.001$) and resistive index (RI: 0.66 ± 0.32 vs. 0.53 ± 0.19 ; $p=0.037$). They also exhibited reduced blood flow velocities: lower end-diastolic velocity (EDV: 6.62 ± 20.02 vs. 15.21 ± 14.03 ; $p=0.012$), peak systolic velocity (PSV: 12.65 ± 35.00 vs. 34.98 ± 24.34 ; $p<0.001$), and MV-flow (3.57 ± 18.50 vs. 15.84 ± 12.24 ; $p<0.001$). Gestational age did not differ significantly between groups (29.24 ± 5.51 vs. 29.22 ± 6.28 weeks; $p=0.9$).

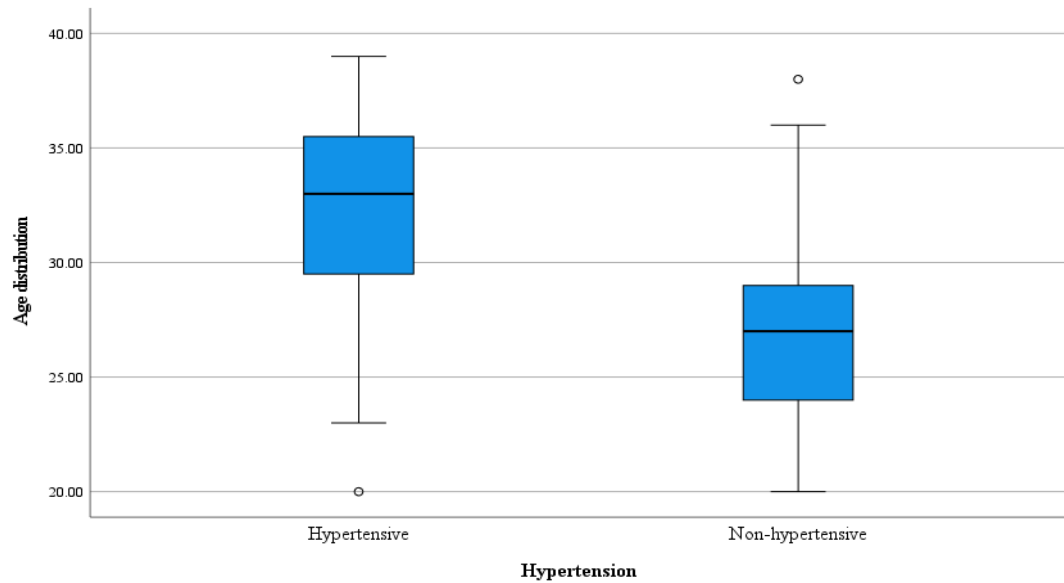


Figure 4.1: Box plot showing distribution of patients according to age

Table 4.1: Comparison of Socioeconomic Status According to Hypertension

Socioeconomic status	Hypertension		Total
	Hypertensive	Non-hypertensive	
Lower	11(20.00%)	11(20.00%)	22(20.00%)
Middle	39(70.90%)	38(69.10%)	77(70.00%)
Upper	5(9.10%)	6(10.90%)	11(10.00%)
Total	55	55	110

This table presents the distribution of socioeconomic status among hypertensive and non-hypertensive pregnant women. Most of the participants in both groups belonged to the middle socioeconomic class (70.90% of hypertensive and 69.10% of non-hypertensive), followed by the lower class (20.00% in both groups), and the upper class (9.10% hypertensive and 10.90% non-hypertensive). The Pearson Chi-Square test indicated no significant association between socioeconomic status and hypertension during pregnancy (p-value = 0.949), suggesting that socioeconomic factors did not influence the occurrence of hypertension in the study population.

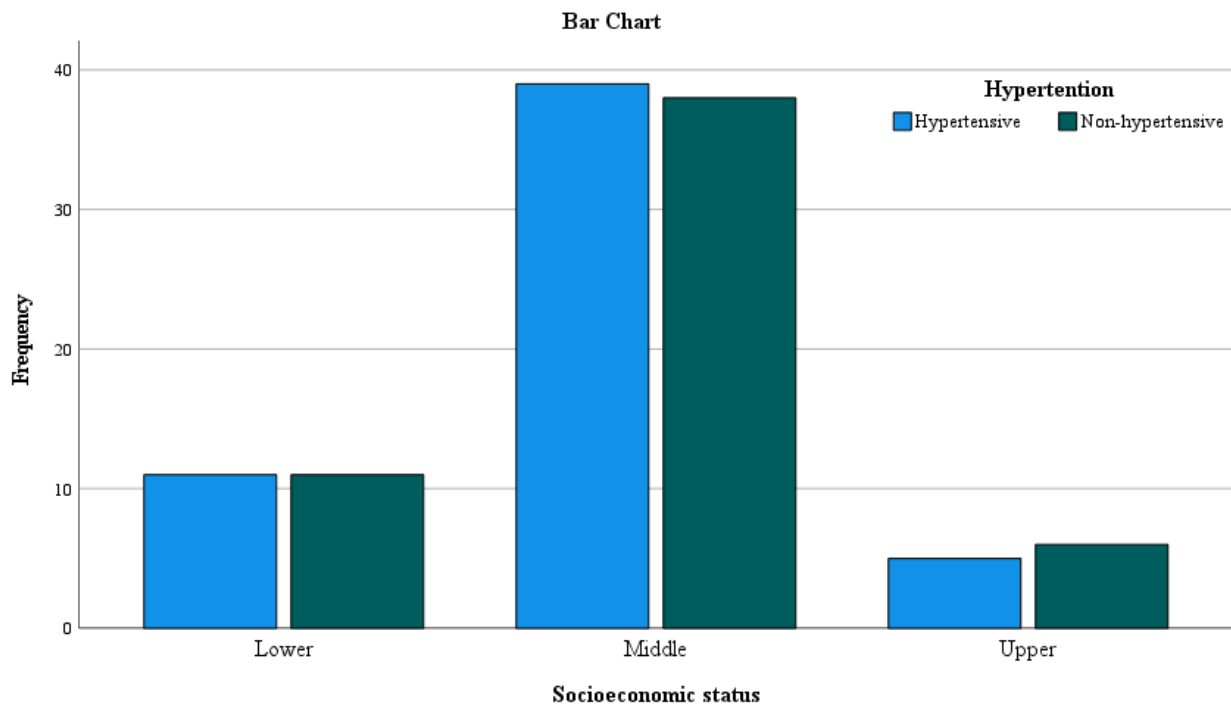


Figure 4.2: Bar chart showing distribution of socioeconomic status by hypertension status

Table 4.2: Parity According to Hypertension

Parity	Hypertension		Total
	Hypertensive	Non-hypertensive	
1	11(20.00%)	8(14.50%)	19(17.30%)
2	25(45.50%)	20(36.40%)	45(40.90%)
3	12(21.80%)	15(27.30%)	27(24.50%)
4	7(12.70%)	12(21.80%)	19(17.30%)
Total	55	55	110

This table summarizes the parity distribution among hypertensive and non-hypertensive women using Mann Whitney U test. Most participants in both groups were multiparous, with parity 2 being the most common (45.50% hypertensive, 36.40% non-hypertensive). There was no statistically significant difference in parity between the two groups (p -value = 0.444), implying that the number of previous births did not significantly influence the development of hypertension during pregnancy in this study.

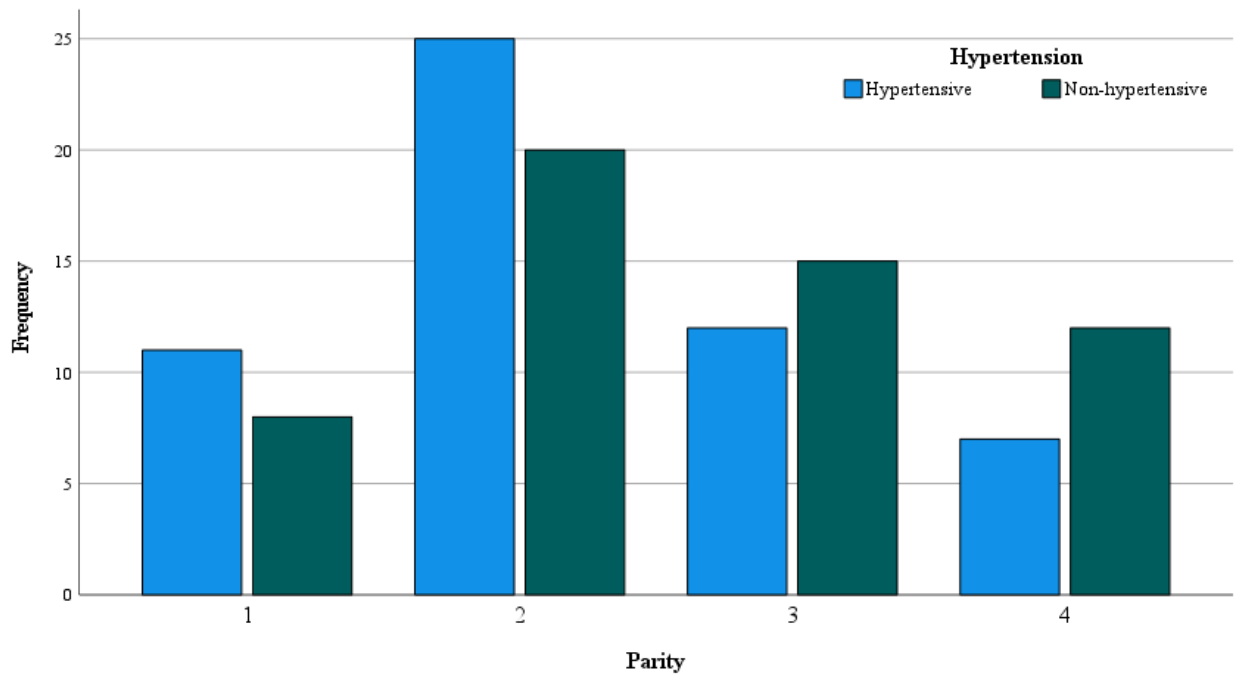


Figure 4.3: Bar chart showing parity distribution by hypertension status

Table 4.3: Amniotic Fluid Index (AFI) According to Hypertension

Amniotic fluid index (AFI)	Hypertension		Total
	Hypertensive	Non-hypertensive	
Adequate	28(50.90%)	39(70.90%)	67(60.90%)
Excessive	27(49.10%)	16(29.10%)	43(39.10%)
Total	55	55	110

This table shows the relationship between hypertension and amniotic fluid index (AFI). In hypertensive pregnancies, nearly half had excessive AFI (49.10%), while the majority of non-hypertensive pregnancies had adequate AFI (70.90%). The association was statistically significant ($p\text{-value} = 0.032$), indicating that hypertensive pregnancies were more likely to be associated with excessive amniotic fluid, which may have clinical implications for maternal and fetal monitoring.

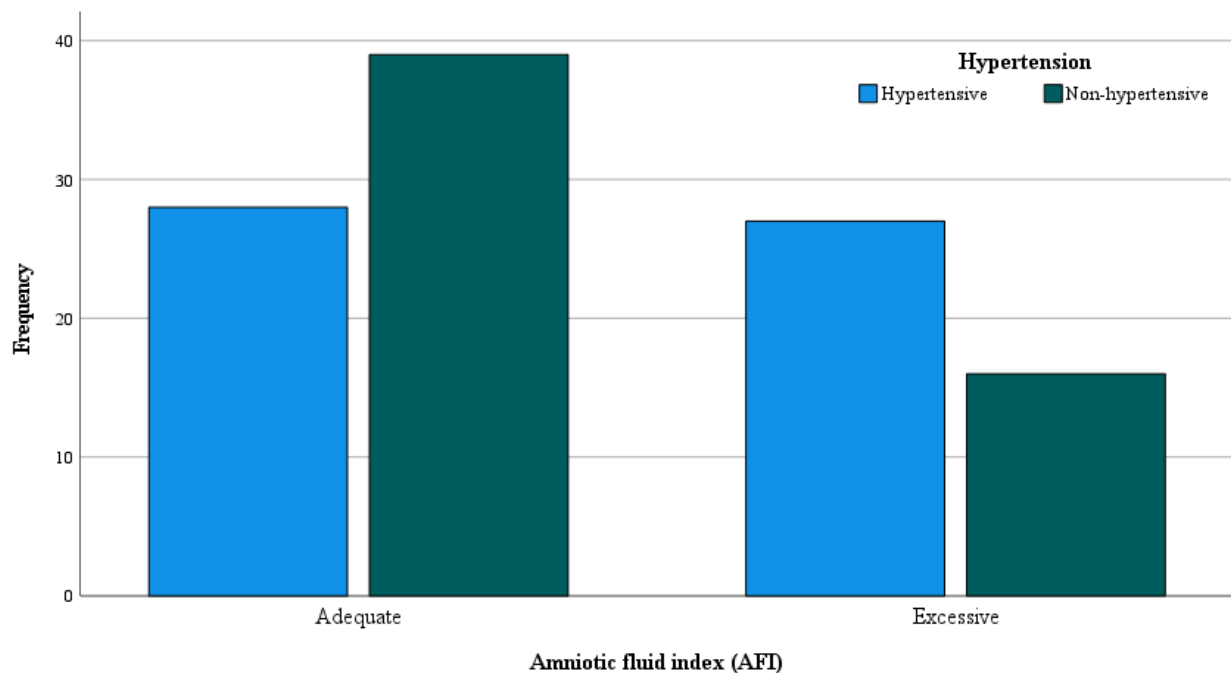


Figure 4.4: Bar chart showing amniotic fluid index distribution by hypertension status

Table 4.4: Comparison of Gestational Age and Systolic Diastolic Ratio

Findings	Hypertension		p-value
	Hypertensive	Non-hypertensive	
Systolic diastolic ratio (SD)	5.39±5.28	2.34±1.98	0.003
Gestational Age	29.24±5.51	29.22±6.28	0.938

This table compares the systolic/diastolic (SD) ratio and gestational age between hypertensive and non-hypertensive pregnancies. While the gestational age was nearly identical in both groups, the SD ratio was significantly higher in hypertensive patients (p-value = 0.003), reflecting increased vascular resistance, a common feature of pregnancy-induced hypertension. This suggests that Doppler findings may be useful in identifying vascular changes associated with hypertensive pregnancies.

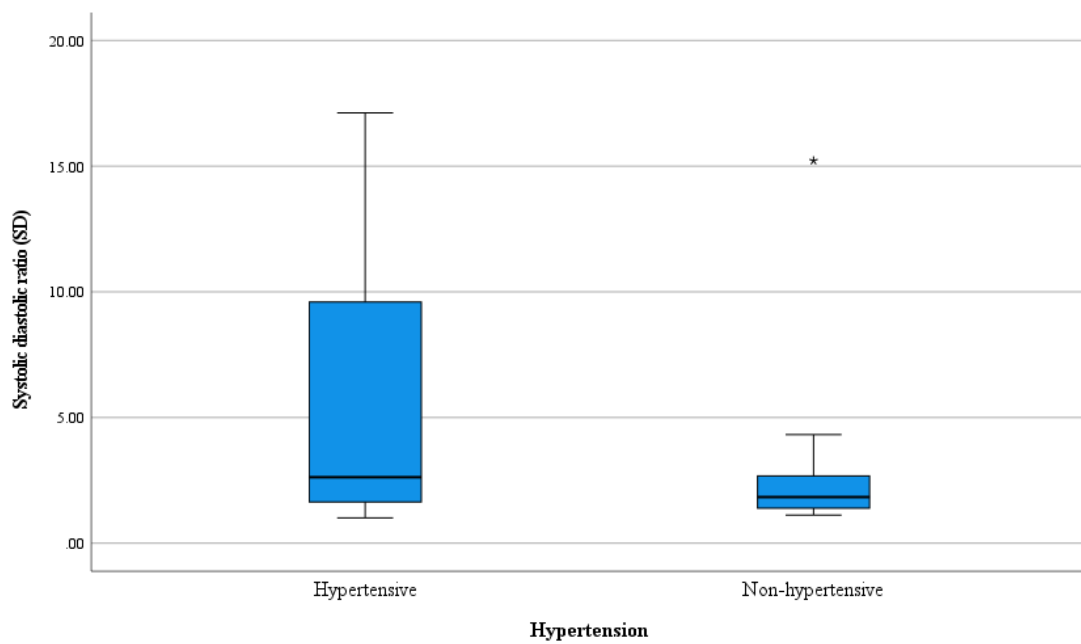


Figure 4.5: Box plot comparing systolic-diastolic ratio by hypertension status

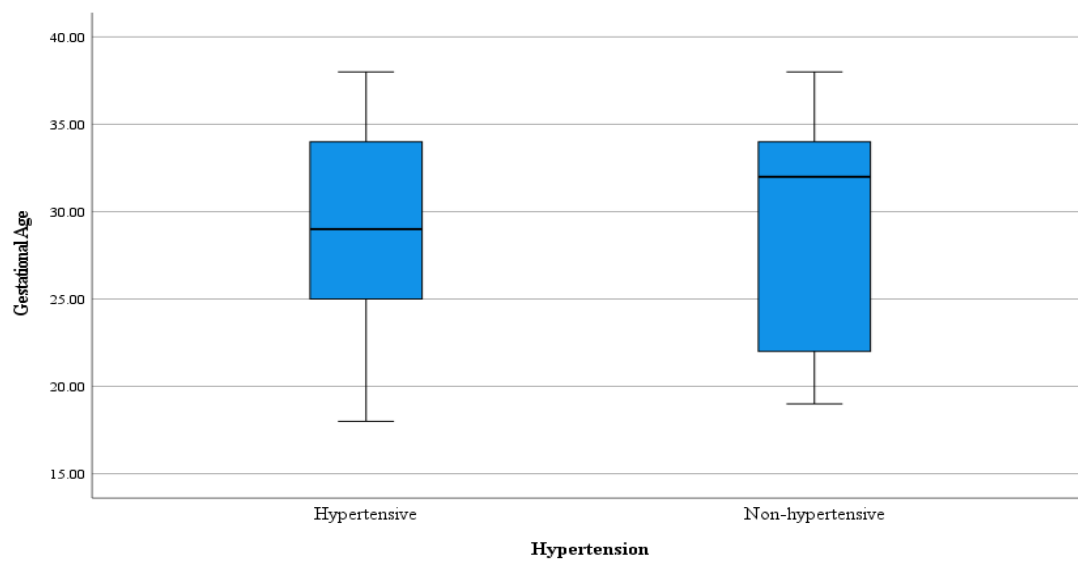


Figure 4.6: Box plot showing Gestational age comparison between hypertensive and non-hypertensive groups

Table 4.5: Comparison of Ultrasound Findings by Hypertension Status

Ultrasound finding	Hypertension		p-value
	Hypertensive	Non-hypertensive	
Pulsatility index (PI)	1.07±0.54	0.74±0.32	0.001
Resistive index (RI)	0.66±0.32	0.53±0.19	0.037

This table highlights the Doppler ultrasound indices (PI and RI) in hypertensive and non-hypertensive pregnancies using Mann Whitney U Test. Both pulsatility index and resistive index were significantly elevated in hypertensive women. These findings are indicative of increased resistance to blood flow in the uteroplacental circulation among hypertensive patients, underscoring the role of Doppler studies in assessing vascular changes in pregnancy

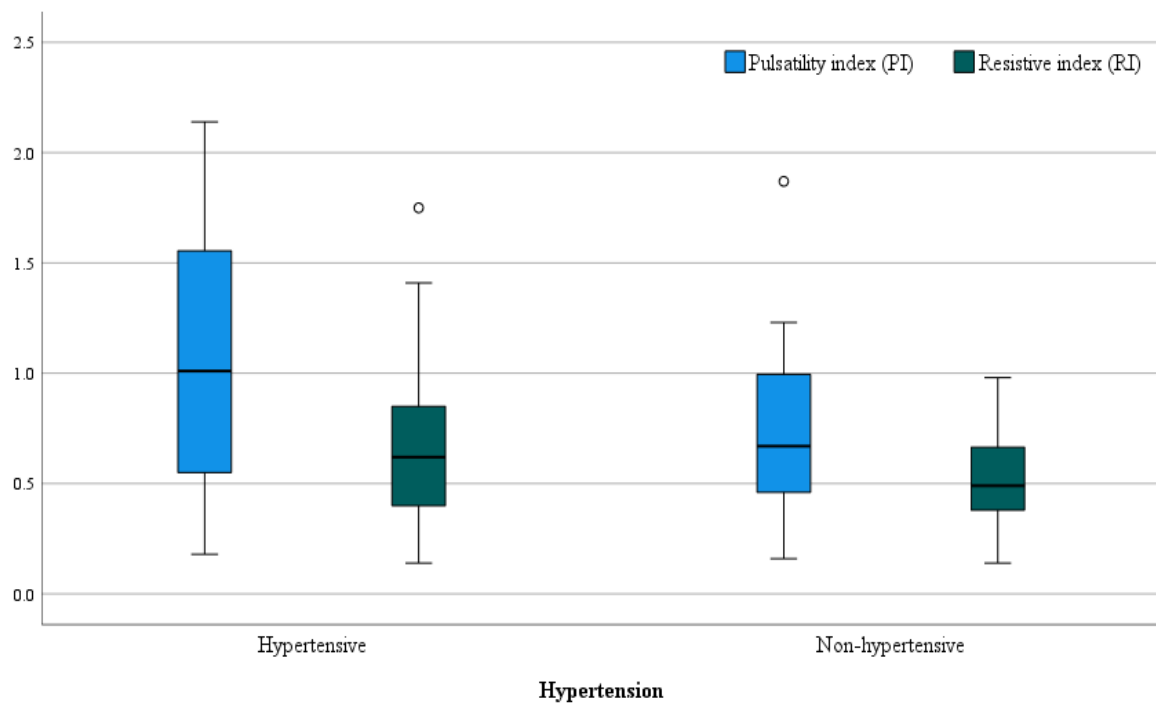
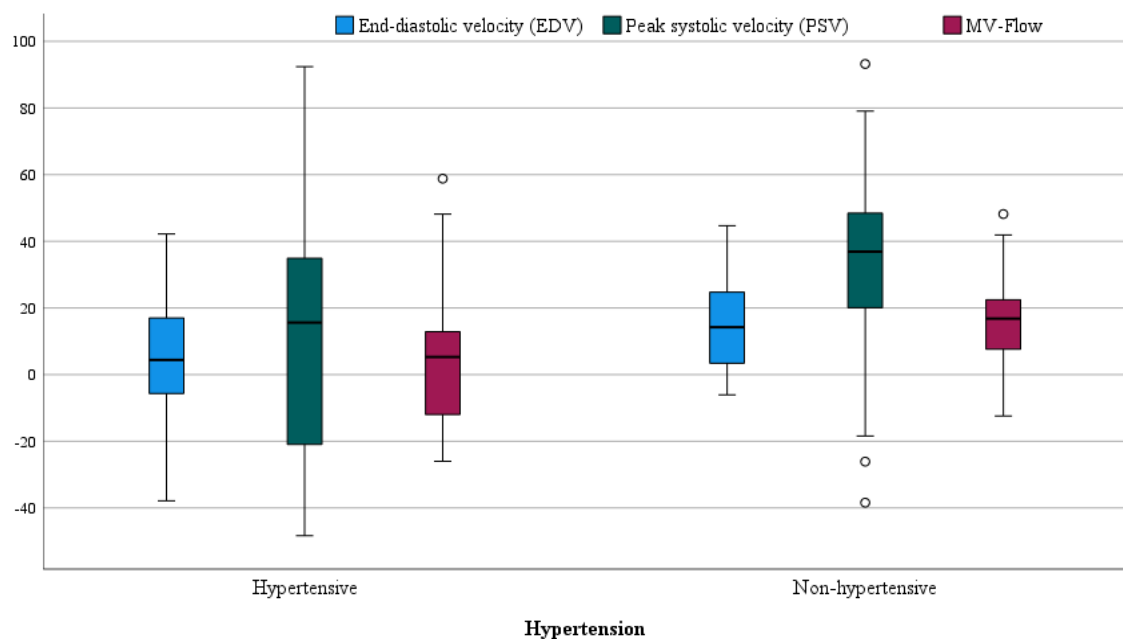


Figure 4.7: Box plot showing Comparison of PI and RI between hypertensive and non-hypertensive pregnancies

Table 4.6: Comparison of Doppler Ultrasound Parameters

Doppler ultrasound	Hypertension		p-value
	Hypertensive	Non-hypertensive	
End-diastolic velocity (EDV)	6.62±20.02	15.21±14.03	0.012
Peak systolic velocity (PSV)	12.65±35.00	34.98±24.34	<0.001
MV-Flow	3.57±18.50	15.84±12.24	<0.001

This table compares advanced Doppler ultrasound parameters between hypertensive and non-hypertensive pregnant women using Mann Whitney U Test. All three measured parameters — EDV, PSV, and MV-Flow — were significantly lower in the hypertensive group, indicating impaired blood flow and reduced vascular compliance. These reductions may reflect compromised placental perfusion and serve as early indicators of fetal compromise in hypertensive pregnancies.

**Figure 4.8: Box plot showing Doppler ultrasound comparison by hypertension status**

CHAPTER 5

DISCUSSION

The purpose of this study was an evaluation of ductus venosus (DV) Doppler waveform parameters in hypertensive and non-hypertensive pregnancies, so as to provide more indicative information about maternal hypertension's effects on fetal hemodynamics and placental function.

The results clearly showed differences between the references of almost all Doppler indices, emphasizing the hemodynamic alterations in fetuses of hypertensive mothers. Hypertensive pregnancies had high systolic-diastolic ((S/D) ratio, pulsatility index (PI), and resistive index (RI), all of which reflected downstream vascular resistance increase. There was a change in end-diastolic velocity (EDV), peak systolic velocity (PSV), and mean velocity (MV-flow), which points to venous return collapse and placental perfusion impairment consistent with findings by Salman et al. (2021), who narrated that mild cases of these abnormalities were attributed to increased placental resistance and diminished trophoblastic invasion.

Resistance indices in hypertensive pregnancies increase with abnormalities in placentation, which occur through an incomplete trophoblastic invasion and failed remodeling of spiral arteries. These processes cumulatively account for a high-resistance, low-flow uteroplacental circulation that prevents effective oxygen and nutrient delivery to the fetus. Thus, alternative mechanisms such as centralization of blood flow emphasizes on the vital organs like the brain and heart. These mechanisms, however, if not able to cope with the increased demands in the circulation, will modify DV hemodynamics- this is occurred early in fetal compromise.

The DV is vital in the fetal circulation, driving well-oxygenated blood from the umbilical vein towards the fetal heart and brain. Due to the structural abnormality by placental insufficiency, there would be increase preload and afterload conditions as well as cardiac strain, decreased diastolic filling, and changes in the DV waveform patterns in hypertensive states. Elevated PI and RI, as noted in this study, are reliable indicators of these pathophysiological changes.

The findings of this study are in accordance with those of El-Demiry et al. (2020) that altered DV indices in pre-eclamptic pregnancies are significant. The contribution highlighted was on the diagnosis of fetal acidemia and adverse perinatal outcomes by reversed or absent A-wave components and predicting with indices reversal or absence. This study has not assessed the A-wave reversal, but elevation in resistance measures and drop in measures of velocity still signal hemodynamic compromise. Similarly, Salman et al. (2021) and Moawad et al. (2022) supported that DV Doppler can detect very early in subclinical fetal distress rather than umbilical artery or middle cerebral artery Doppler investigation. The reported Doppler abnormalities in this study reinforce the idea that the DV is a much closer interpreter of cardiac function and central venous pressure.

Interestingly, in this study, it was found that hypertensive pregnancies were associated with more incidence of high amniotic fluid index, which goes against most literature findings. Oligohydramnios has been reported in such pregnancies by Berhe et al. (2020) and Madhu P. (2020). There are many possible explanations for this: variations in diagnostic thresholds, interobserver variability, population-specific factors, and concomitant conditions, such as gestational diabetes, which were not controlled in this study.

This study emphasizes the potential way by which DV Doppler could act in an early biomarker for fetal compromise in hypertensive pregnancies. This means that it is noninvasive and has a high sensitivity factor for cardiac preload and central venous pressure. Therefore, it serves as another adjunct to the traditional umbilical and uterine artery Doppler evaluations. Incorporating the DV Doppler in routine antenatal monitoring, particularly in high-risk populations like women with gestational hypertension and women with preeclampsia, might allow an Earlier identification of fetal decompensation, Timely decisions regarding corticosteroid administration and delivery and an Improved neonatal outcome by risk stratification.

More importantly, DV Doppler results will be the best guides for individualized management such as oxygen therapy, antihypertensive adjustment, and possibly hospitalization for continuous fetal surveillance

CONCLUSIONS

This study explored the ductus venosus Doppler waveform parameters in hypertensive versus non-hypertensive pregnancies and demonstrated that maternal hypertension is related with noticeable alterations in fetal venous hemodynamics. Specifically, hypertensive pregnancies showed elevated pulsatility and resistive indices, along with reduced systolic and diastolic flow velocities, indicating increased vascular resistance and compromised fetal perfusion. These findings support the use of DV Doppler as an effective, non-invasive tool for early detection of fetal compromise in high-risk pregnancies.

The results are consistent with existing literature and reinforce the pathophysiological basis that maternal hypertension leads to placental insufficiency and increased fetal cardiac afterload. The inclusion of DV Doppler assessments in routine antenatal care for hypertensive patients may allow for better monitoring and timely interventions, ultimately improving perinatal outcomes.

Limitation

- Although adequate from a statistical point of view, the use of a convenient sampling design might have resulted in selection bias and consequently affected the generalizability of the results.
- All data were collected from a single ultrasound clinic which may not reflect the true population or any variations in the clinical practice that may occur in different settings.
- The cross-sectional design allowed no assessment of how Doppler changes progressed over time or correlated with neonatal outcomes after delivery.
- The absence of neonatal follow-up or perinatal outcome data would have enriched our understanding of the clinical significance of the Doppler findings.

Recommendations

- To make it of use for the scientific community, the multicenter studies will assess the temporal variations of DV Doppler and correlate it with neonatal outcomes.
- Comparative studies involving other Doppler parameters: umbilical artery, uterine artery, MCA along with DV indices will provide a more complete understanding of fetal hemodynamics in hypertensive pregnancies.
- Training and Standardization: Sonographer should be trained adequately in DV Doppler methods to minimize interobserver variation and assure optimal waveform acquisition and interpretation.

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APPENDICES

ENGLISH CONSENT FORM

The study you are about to participate is a randomized control trial survey titled as;

“COMPARISON OF DUCTUS VENOSUS
DOPPLER WAVEFORM IN HYPERTENSIVE AND
NON-HYPERTENSIVE PREGNANCIES”

The study has no potential harm to participants. All data collected from you will be coded to protect your identity, and should not be disclosed to anyone. Following the study there will be no way to connect your name with your data. Your answers to the questions will not affect the quality of education given to you. Any additional information about the study results will be provided to you at its conclusion, upon your request.

You are free to withdraw from the study at any time. You agree to participate, indicating that you have read and understood the nature of the study, and that all your inquiries concerning the activities have been answered to your satisfaction.

NAME: Khawaja Ruman Ahmad

SIGNATURE_____

DATE_____

URDU CONSENT FORM

میں خواجہ رومان احمد تصدیق کرتا/ کرتی ہوں کہ محترم نے اپنی اس تحقیق

”ہائی بلڈ پریشر اور غیر ہائی بلڈ پریشر والے حمل میں ڈاکٹس وینس ڈوپلر ویوفارم کا موازنہ“

زیرنگرانی ڈاکٹر محمد عدنان حفیظ کے متعلق بتا دیا ہے۔ مجھے اس تحقیق کی نوعیت، مقاصد،

احداف، توقعات، فوائد اور خطرات کے متعلق ، ساری معلومات فراہم کر دی گئی ہیں

اس تحقیق کے دوران ساری معلومات صیغہ راز میں رہیں گی اور مریض کا نام اور دیگر معلومات

صرف تحقیق کے لیے استعمال ہوں گی۔ مجھے یہ بھی بتا دیا گیا ہے کہ میں اس تحقیق سے متعلقہ

ہر قسم کے سوال پوچھنے کا مجاز ہوں اور یہ تحقیق صرف ایک شخص ک مفاد میں نہیں ہے بلکہ

بحسبیت مجموعی انسانیت کا مفاد اس سے وابستہ ہے۔ تمام تفصیلات جاننے کے بعد یس تحقیق

میں شامل ہونے یا نہ ہونے پر کسی کا قائل نہیں ہوں۔ اس تحقیق سے کسی بھی وقت علیحدہ ہونے

پر مجھ پر کوئی پابندی نہیں ہو گی۔ میں بذاتِ خود بقائمی حوش و حواس

اور رضا مندی سے اس تحقیقاتی عمل میں شامل ہوتی/ ہوتا ہوں

دستخط محقق _____

دستخط شرکت کار _____

تاریخ _____

DEMOGRAPHICS FORM & QUESTIONNAIRES

DATA COLLECTION SHEET (single patient)

Questionnaire:

Sr. No: _____

Age: _____

Socio-economic status: _____

Parity: _____

Hypertensive: YES/NO

Ultrasound Findings:

- Gestational Age by USG: _____
- Gestational Age by LMP: _____
- AFI Volume: _____

Doppler Finding:

Ductus Venosus S/D Ratio (SDR): _____

Pulsatility Index (PI): _____

Resistive Index (RI): _____

End-diastolic Velocity (EDV): _____

Peak-systolic Velocity (PSV): _____

Mean Velocity (MV): _____

PERMISSION LETTER



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Rx

Date: April 07, 2025

To Whom It May Concern,

This letter serves to formally grant Mr. Khawaja Ruman Ahmad, a postgraduate student of MS Medical Imaging Technology, permission to conduct data collection for his research study titled:

“Comparison of Ductus Venosus Doppler Waveform in Hypertensive and Non-Hypertensive Pregnancies”

He has been authorized to collect relevant clinical data from Gilani Ultrasound Center, under proper ethical guidelines and in accordance with the confidentiality and privacy standards required for human subject research.


Admin Manager GUC
07-04-2025

آئندہ الٹراساؤنڈ کروانے کے لئے یہ رپورٹ ضرور ساتھ لائیں۔

ETHICS COMMITTEE LETTER



OFFICE OF THE DEAN-FAHS

SUPERIOR UNIVERSITY

Ref: IRB /FAHS/Allied/04/25/MS/AHS-3704

Date: 18th March 2025

Program: MS Allied Health Sciences

Name: Khawaja Ruman Ahmad

Registration: SU91-MSAHW-F23-002

Subject: Ethical Approval Letter

The Research Ethical Committee convened on Dated: **17th March, 2025** to discuss your protocol titled **"Comparison Of Ductus Venosus Doppler Waveform in Hypertensive and Non-Hypertensive Pregnancies"**

No further corrections and recommendations were suggested. The above-mentioned protocol has been approved after considering various research issues including ethical concerns with condition that the researcher will submit completion report at the end of his/her research.

A handwritten signature in black ink, appearing to read 'Dr. Naveed Babur'.

Prof. Dr. Muhammad Naveed Babur
Dean/Convener REC
Faculty of Allied Health Sciences
Superior University, Lahore

17-KM, Main Raiwind Road, Lahore.
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PLAGIARISM REPORT

Report: Comparison of Ductus Venosus Doppler Waveform in Hypertensive and Non Hypertensive Pregnancies (Khawaja Ruman Ahmad)

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