The Research of Medical Science Review

Received: 15 December, 2024 ISSN: 3007-1208 | 3007-1216
Accepted: 15 January, 2025 Volume 3, Issue 1, 2025
Published: 24 January, 2025

DOPPLER EVALUATION OF UMBILICAL ARTERY FLOW PATTERN IN ANEMIC PREGNANT WOMEN

Faiza Haq Nawaz[1], Hafiz Ayaz Ahmad[2], Laiba Tariq[3], Areej Faisal[4], Jahanzaib[5]

*[*1]Postgraduate Student,MS Diagnostic Ultrasound(Allied Health Sciences)
Department of Radiological Sciences and Medical Imaging Technology, the Superior University, Lahore, Pakistan*
[2]Lecturer,Department of Medical Lab Technology-Faculty of Allied Health Sciences, the Superior University, Lahore, Pakistan
[4]Postgraduate Student,MS Diagnostic Ultrasound(Allied Health Sciences)
*[3,5]Postgraduate Student,MS Medical Imaging Technology(Allied Health Sciences)
Department of Radiological Sciences and Medical Imaging Technology, the Superior University, Lahore, Pakistan*

[*1]faizahaqnawaz7@gmail.com

DOI: https://doi.org/10.5281/zenodo.14729456

ABSTRACT

Objective: *To evaluate umbilical artery doppler indices in anemic pregnant women for reducing adverse effects of anemia on maternal and fetal health.The study aims to contribute to the understanding of how anemia and other forms of anemia affect pregnancy outcomes, particularly in the context of placental function. Additionally, the study seeks to assess the predictive value of Doppler velocimetry in this setting, providing valuable insights into its potential role in the early detection of complications*

Study design: *It was a Descriptive cross-sectional study design.*

Place and duration of study: *The study was conducted at THQ Hospital Pattoki, Pakistan from August to December 2024.*

Material and Methods: *This study follows a descriptive, cross-sectional research design, which is appropriate for evaluating and analyzing the umbilical artery flow patterns in pregnant women diagnosed with anemia at a particular point in time. The study design aims to describe the relationship between anemia severity and Doppler ultrasound findings in pregnant women and evaluate the prevalence of abnormal flow patterns in the umbilical artery.*

Results: *The study involved 72 anemic pregnant women with a mean gestational age of 26.44 weeks (SD = 4.82), indicating mid-pregnancy. The average Body Mass Index (BMI) was 26.39 (SD = 1.62), suggesting that most participants were slightly overweight. Hemoglobin levels averaged 10.29 g/dL (SD = 1.21), reflecting mild anemia, with values ranging from 7.8 to 12.9 g/dL. In terms of Doppler ultrasound parameters, 65.3% of participants (47 cases) had a normal systolic/diastolic (S/D) ratio, indicating stable placental perfusion. However, 26.4% (19 cases) showed moderate abnormalities, and 8.3% (6 cases) exhibited severe abnormalities. Regarding the Resistance Index (RI), 70.8% (51 cases) had normal values, suggesting good vascular conditions, while 27.8% (20 cases) showed moderate changes, and 1.4% (1 case) had severe abnormalities. For the Pulsatility Index (PI), 41.7% (30 cases) of participants had normal values,* *while 48.6% (35 cases) showed moderate changes, and 9.7% (7 cases) had severe abnormalities, indicating a need for clinical intervention in some cases. Crosstab analysis revealed that a majority of participants with mild and moderate anemia had normal RI values, with 21 cases each in the mild and moderate anemia categories showing normal RI. However, the chi-square test revealed no significant association between hemoglobin levels and RI categories (p=0.434p = 0.434p=0.434). Similarly, for the S/D ratio, 65.3% of mild and moderate anemia cases exhibited normal values, but no significant association was found between hemoglobin levels and S/D ratio (p=0.281p = 0.281p=0.281). Likewise, in the case of PI, moderate PI abnormalities were most common among those with mild and moderate anemia, but again, no significant correlation between hemoglobin levels and PI was observed (p=0.157p = 0.157p=0.157). Regarding maternal weight, 50% (36 cases) of participants were of normal weight, 20% (14 cases) were underweight, and 10% (7 cases) were overweight. The results underscore the clinical significance of monitoring Doppler parameters in anemic pregnant women, as Doppler abnormalities were more prevalent despite the absence of significant statistical associations. These findings suggest the need for further research with larger sample sizes to explore potential causal relationships and refine management strategies for anemia in pregnancy, emphasizing the importance of clinical observation in managing placental perfusion and maternal-fetal health.*

Conclusion:*This study provides valuable insights into the Doppler evaluation of umbilical artery flow patterns in anemic pregnant women. The findings suggest that while many participants exhibited normal Doppler parameters, such as the systolic/diastolic (S/D) ratio and resistance index (RI), a significant portion of the sample demonstrated moderate pulsatility index (PI) abnormalities, indicating a potential compromise in placental perfusion. Despite the prevalence of mild and moderate anemia, the chi-square analysis revealed no significant association between hemoglobin levels and Doppler parameters, highlighting the complexity of anemia in pregnancy. This lack of significant correlation suggests that other factors, aside from hemoglobin levels, may contribute to abnormal Doppler findings. Additionally, the study underscores the importance of continued clinical observation and the need for further investigation into the mechanisms behind Doppler abnormalities in anemic pregnancies. Larger sample sizes and more in-depth studies are needed to better understand the relationship between anemia, placental perfusion, and fetal outcomes. Overall, the study emphasizes the clinical importance of Doppler assessments as a tool for monitoring placental health in pregnant women with anemia, and advocates for further research to improve the diagnosis and management of anemia in pregnancy to enhance maternal and fetal health outcomes.*
Keywords: *Anemia, Doppler, Umbilical artery, Peak systolic velocity*

INTRODUCTION

The umbilical cord is visible throughout pregnancy and can be detected sonographically as soon as the fetal pole is visible. The umbilical cord is usually 50-60 cm long and can twist up to 40 times to the left. An understanding of development, normal sonographic appearance, and major umbilical cord anomalies is essential in fetal evaluation. The peduncle, omphalomesenteric, yolk sac, and allantois all help produce the umbilical cord between weeks 5 and 12 of pregnancy [1]. A double sac is one of the first signs of pregnancy on sonography. Wharton's jelly, a gelatinous material consisting mainly of mucopolysaccharides, covers the blood vessels inside the umbilical cord. It has one vein that brings oxygenated, nutrient-rich blood to the fetus and two arteries that carry deoxygenated, nutrient-poor blood away from the fetus [2]. The size, degree of coiling, attachment, and position of the umbilical cord can all have an effect on pregnancy prognosis.

Anemia is defined as a decrease in the number of red blood cells or a decrease in the amount of hemoglobin in the blood. The condition is defined as existing in an individual whose hemoglobin (Hb) concentration has fallen below a threshold lying two standard deviations below the median for a healthy population with the same demographic characteristics, including age, sex, and pregnancy status. Iron deficiency anemia, aplastic anemia,

sickle cell anemia, and vitamin deficiency anemia are all examples of anemia. Anemia can be caused by a condition that is present at birth (congenital) or a condition that develops over time (acquired) [3].
Anemia during pregnancy remains a prevalent health condition globally, particularly in developing countries. It is characterized by a reduction in hemoglobin levels below the normal threshold, leading to insufficient oxygen supply to both the mother and the developing fetus. This condition has been associated with numerous maternal and fetal complications, including preterm birth, low birth weight, small for gestational age (SGA) infants, and placental insufficiency. While the global prevalence of anemia during pregnancy has decreased in recent decades due to better awareness and nutritional interventions, it remains a major public health challenge, especially in low-resource settings. In many parts of the world, iron deficiency anemia (IDA) is the most common cause of anemia during pregnancy, often resulting from insufficient dietary intake of iron and other essential nutrients. However, anemia can also result from other causes, including chronic diseases, hemoglobinopathies, and infections. The consequences of anemia are particularly concerning in the context of pregnancy, as it not only impacts maternal health but can also have adverse effects on fetal development, leading to growth restriction, preterm birth, and other neonatal complications. As such, anemia during pregnancy is a critical factor that requires timely identification, monitoring, and intervention to prevent negative outcomes. Iron deficiency is the most common nutritional problem worldwide, especially in pregnant women [4]. Anemia during pregnancy can also be caused by parasitic infections such as malaria, hookworms, and schistosomiasis; deficiency of micronutrients such as folic acid, vitamin A, and vitamin B12; and hereditary hemoglobinopathies such as thalassemia and Helicobacter pylori [5,6]. Anemia is defined as a hemoglobin level of less than 11 g per dl in the first and third trimesters and less than 10.5 g per dl in the second trimester according to the Centers for Disease Control in 1989 [7]. Anemia during pregnancy is a major public health problem worldwide, especially in developing countries. The greatest burden of anemia was reported in Asian and African countries (60 and 52%, respectively) [8,9]. Women of childbearing age, pregnant women, premature babies with low birth weight, older infants and toddlers, and teenage girls are at the greatest risk of developing iron deficiency anemia. About 80% of pregnant women with anemia are expected to live in South Asia, 56% in developing countries, and 18% in developed countries [10]. Maternal anemia is a hypoxic condition that could be responsible for the redistribution of fetal blood flow; however, no evidence of placental insufficiency has been documented at present [11]. Anemia in the first trimester of pregnancy has been shown to be a risk factor for preterm birth (age less than 37 weeks of gestation), but several studies have not supported this relationship [12,13].
So far, various studies have been conducted around the world to measure the relationship between maternal anemia during pregnancy and preterm birth. This relationship was significant in some studies, but in other studies, there was no significant relationship. In this study, we put all the evidence side by side by conducting a meta-analysis to present a more accurate picture of the problem in the world. This method is more reliable due to certain meta-analysis conditions. During a normal pregnancy, various physiological changes occur, including changes in the patient's hemodynamic status. Plasma volume increases by 10% to 15% at 6 to 12 weeks of gestation and rapidly expands until 30 to 34 weeks, after which there is only a modest rise [14,15]. The total gain at term averages 1100 to 1600 ml and results in a plasma volume of 4700 to 5200 ml, which is 30 to 50% more than in non-pregnant women. This results in physiologic anemia during pregnancy, and in women who already have underlying anemia, the condition is exaggerated. Maternal anemia, sometimes reaching very low levels (maternal hemoglobin level, 40-50 g/l), is often associated with prematurity, low birth weight, and iron deficiency in the infant. The physiological changes that occur during pregnancy, such as increased blood volume, contribute to the development of anemia. As blood volume increases, there is a relative dilution of red blood cells, which may result in lower hemoglobin levels. However, when hemoglobin levels fall below a certain threshold, the capacity to carry oxygen is compromised, leading to hypoxia in maternal tissues and potentially the fetus. This can adversely affect fetal development, particularly placental function, which is responsible for providing oxygen and nutrients to the developing fetus. Inadequate oxygen delivery to the fetus can lead to a cascade of complications, including placental insufficiency, fetal growth restriction, and preterm birth. Studies have demonstrated that anemic women, particularly those with iron deficiency anemia, are at increased risk of delivering preterm and low birth weight infants. Additionally, anemia has been linked to poor maternal health outcomes, including cardiovascular strain, increased risk of infections, and postpartum hemorrhage.

Doppler sonography is a non-invasive method of assessing blood flow in the fetoplacental circulation and is considered the gold standard in the assessment of fetal hemodynamics. In recent years, Doppler velocimetry has emerged as a useful tool for monitoring fetal well-being, especially in pregnancies complicated by conditions like anemia and preterm birth. Doppler ultrasonography measures blood flow through various vessels, such as the umbilical artery, middle cerebral artery, and uterine arteries, providing insight into placental blood flow. Abnormal Doppler indices, such as increased S/D (systolic/diastolic) ratios or reversed end-diastolic flow, suggest placental insufficiency and may be associated with adverse outcomes, including fetal growth restriction and preterm birth. Several studies have shown that placental insufficiency, as indicated by abnormal Doppler findings, can lead to poor fetal outcomes. Reversed end- diastolic flow, in particular, is considered a marker of severe placental insufficiency and is strongly correlated with preterm birth and small for gestational age infants. Given the potential for Doppler velocimetry to predict these outcomes, it has been widely incorporated into clinical practice to assess pregnancies at high risk for complications. However, its utility in the setting of anemia remains an area of ongoing research. The umbilical artery is used to assess placental function. The Doppler test is a clinical test that can tell the difference between modest GA and IUGR [16,17]. The ratio of cerebral to umbilical artery resistance is used to quantify Doppler ultrasonography. The length of pregnancy has little effect on this Doppler parameter, which is always more than 1.1 during a normal pregnancy. However, in the presence of hypoxia, this ratio decreases due to increased placental resistance and cerebral vasodilation and is closely correlated with fetal growth, hypoxia, and behavior, especially before 34 weeks of gestation [18]. The umbilical artery resistance index has a statistically significant association ($P< 0.05$). Umbilical artery resistance index in the range of 0.50-0.68, in mild anemia 0.54-0.71, in moderate anemia 0.59-0.74 and in severe anemia 0.60-0.77. There is a statistically significant relationship regarding the umbilical artery pulsatility index ($P < 0.05$). The umbilical artery pulsatility index ranges from 0.77-0.85, for mild anemia it ranges from 0.60-0.88, for moderate anemia it ranges from 0.67-0.90, for severe anemia ranges from 0.77-1.80. There is a statistically significant relationship between the different study groups regarding the systolic/diastolic ratio of the umbilical artery ($P < 0.05$). Umbilical artery systolic/diastolic ratio ranges from 2.09-2.2, in mild anemia 2.13-2.23 with an intermediate value, in moderate anemia 2.10-3.40, and in severe anemia 2.15 -4.30. Time-averaged peak or peak systolic velocities (PSV) of the MCA have been used in the prediction and treatment of fetal anemia in the clinical setting of fetal anemia and Rh isoimmunization [8,9]. For this application, PSV relates to normative gestational data and is used to predict the presence of fetal anemia. Abnormal waveforms (mainly loss of forward end-diastolic flow velocity) in umbilical arteries in many pregnancies may be complicated by either preeclampsia or severe IUGR and provide important insight into their pathophysiology. Umbilical artery Doppler sonography combined with biometry provides the best tool to identify small fetuses at risk of adverse outcomes [20]. Various studies have demonstrated its usefulness in improving obstetric outcomes. While Doppler velocimetry has shown promise in detecting placental insufficiency, its role in pregnancies complicated by anemia has not been fully elucidated. The relationship between anemia and adverse pregnancy outcomes, such as preterm birth and SGA infants, is complex and influenced by a variety of factors, including the timing of anemia (whether it occurs in the first, second, or third trimester), its severity, and other underlying maternal conditions such as hypertension or nutritional deficiencies.

The current study, conducted at Tehsil Head Quarters Hospital Pattoki, aims to investigate the radiological characteristics of 72 patients with confirmed anemia during pregnancy, with a particular focus on the utility of Doppler velocimetry in predicting fetal outcomes. This study seeks to explore the following key questions:

What is the relationship between anemia (in its various forms) and adverse pregnancy outcomes such as preterm birth, low birth weight, and SGA infants?

Can Doppler velocimetry, including the assessment of S/D ratios and end-diastolic flow, provide predictive value in anemia-related pregnancies?

Are there differences in the Doppler indices and pregnancy outcomes between different severities of anemia (mild, moderate, and severe)?

By exploring these questions, the study aims to contribute to the understanding of how anemia and other forms of anemia affect pregnancy outcomes, particularly in the context of placental function. Additionally, the study seeks to assess the predictive value of Doppler velocimetry in this setting, providing valuable insights into its potential role in the early detection of complications. Due to poor socio-economic status, many women in our society suffer from poor health as well as low HB levels. In this regard, pregnancy causes more suppression of HB levels, and many women suffer from anemia. Anemia causes numerous complications in these women. Due to the lack of information and organized data, these patients have no idea how to manage this situation in time, which can reduce the severity of complications. This research will provide organized data about this problem prevalent in our society, which will give awareness to people and doctors to deal with it properly and timely. The findings of this study could have important implications for prenatal care and clinical practice, particularly in settings where iron deficiency anemia is prevalent. If Doppler velocimetry proves to be a useful tool in identifying at-risk pregnancies with anemia, it could be incorporated into routine screening, leading to earlier interventions and improved outcomes. Furthermore, by clarifying the relationship between anemia and adverse pregnancy outcomes, this research could guide better management strategies for pregnant women with anemia, reducing the incidence of preterm birth, SGA infants, and other complications.

Materials & Methods

This descriptive, cross-sectional study was conducted over six months at Tehsil Head Quarters Hospital, Pattoki. Seventy-two pregnant women diagnosed with anemia (hemoglobin < 11 g/dL in the first and third trimesters, or < 10.5 g/dL in the second trimester) were included. Women aged 18-35 with singleton pregnancies were recruited, excluding those with chronic conditions, multiple pregnancies, or fetal anomalies.

Demographic and clinical data were collected, and anemia severity was categorized as mild, moderate, or severe based on hemoglobin levels. All participants underwent ultrasound evaluations, including fetal growth assessments and Doppler velocimetry of the umbilical, middle cerebral, and uterine arteries using the GE Voluson 730 ultrasound system.

Primary outcomes included preterm birth, low birth weight, and small for gestational age infants. Secondary outcomes focused on fetal growth restriction and neonatal complications. Data analysis was performed using SPSS version 25.0, employing descriptive statistics, chi-square to assess relationships between Doppler indices and anemia severity. Ethical approval and informed consent were obtained.

Results

The demographic and clinical data that can be gleaned from the analysis of the Doppler evaluation of umbilical artery flow patterns in anemic pregnant women is insightful. In total, 72 participants were involved in the study, with a mean gestational age of 26.44 weeks (SD = 4.82), thus mid-pregnancy. The mean Body Mass Index was recorded as 26.39 (SD = 1.62), which means that most of the participants were slightly overweight. Hemoglobin levels averaged at 10.29 g/dL (SD = 1.21), indicating mild anemia throughout the sample, with values ranging from 7.8 to 12.9 g/dL.

TABLE 1: Gestational Age

		Gestational Age	BMI	Hb
Sample (N)	Valid	72	72	72
	Missing	0	0	0
Mean		26.44	26.390	10.28889
Std. Deviation		4.820	1.6173	1.209418
Minimum		20	24.0	7.800
Maximum		35	29.2	12.900

This table presents the statistical summary of Gestational Age, BMI, and Hb levels. It includes the total number of valid cases (N=72) and no missing data for these variables. The mean gestational age is 26.44 weeks, BMI is 26.39, and hemoglobin (Hb) is 10.29 g/dL. The standard deviations indicate variability: 4.82 weeks for gestational age, 1.62 for BMI, and 1.21 g/dL for Hb. The minimum and maximum values provide the range for each variable.

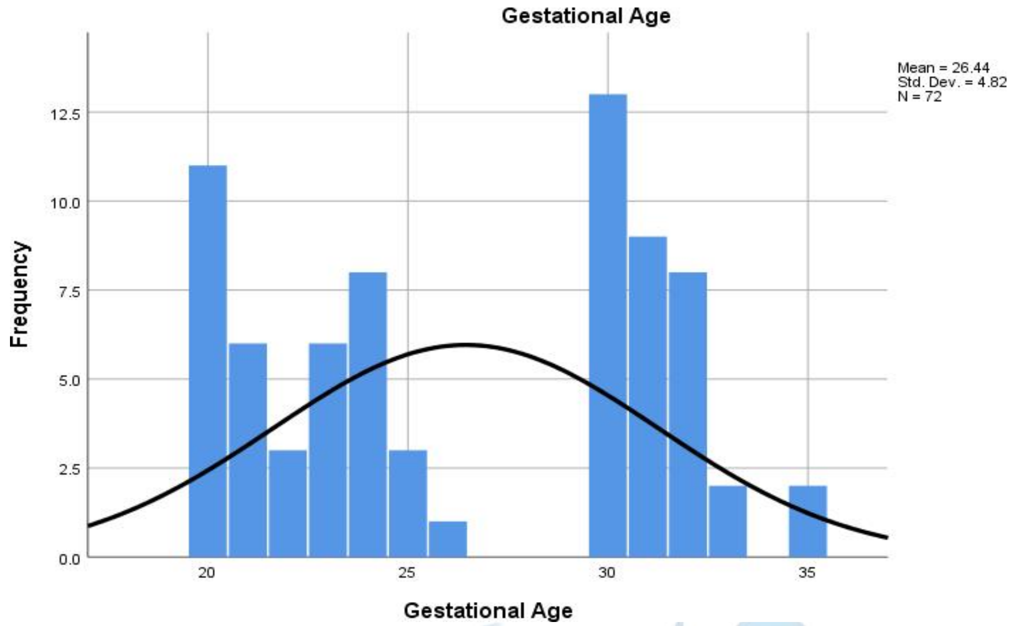

FIGURE 1.1: Histogram representation of Gestational Age of patients

Gestational Age has an average of 26.44 weeks, with a variability of 4.82 weeks, ranging from 20 to 35 weeks.

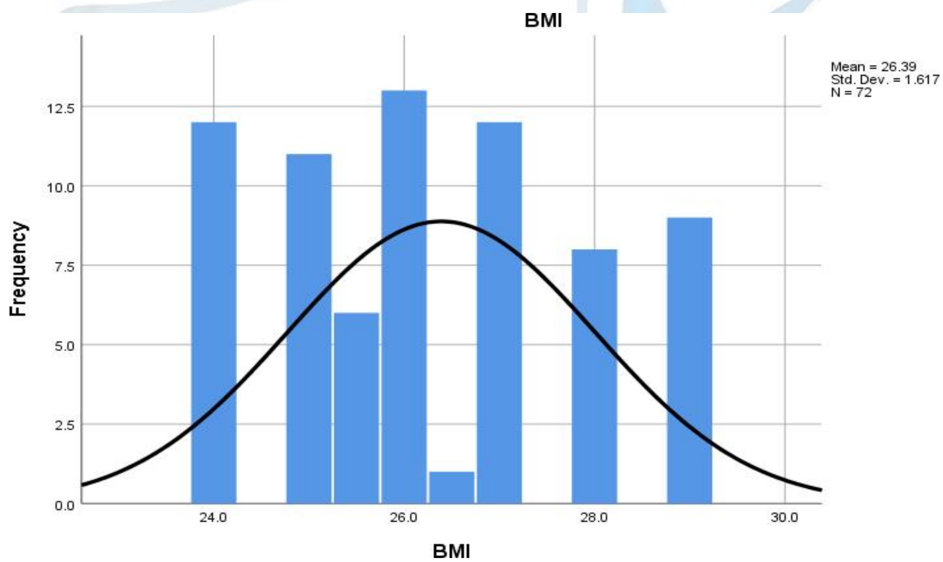

FIGURE 1.2: A Histogram representation of BMI of patinets

BMI shows a mean value of 26.39, indicating a slightly above-average body mass index among the participants, with a range from 24.0 to 29.2.

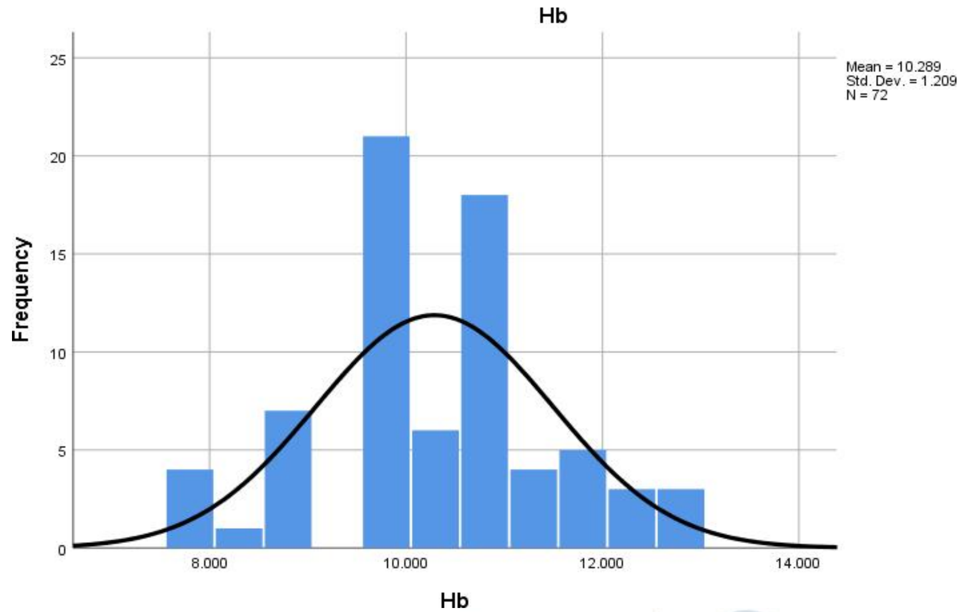

FIGURE 1.3: A Histogram representation of Hb of Patients

Hemoglobin (Hb) has an average level of 10.29 g/dL, suggesting mild anemia on average, with levels varying from 7.8 to 12.9 g/dL. This range highlights the clinical diversity within the sample population.

TABLE 2: Distribution of different clinical parameters of the study participants

		s/d Ratio		Patient Age		RI		PI		Hb_1	
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	P
	Normal	47	65.3	32	44.4	51	70.8	30	41.7	30	4
	Moderate	19	26.4	24	33.3	20	27.8	35	48.6	27	3
	Severe	6	8.3	16	22.2	1	1.4	7	9.7	15	2
	Total	72	100.0	72	100.0	72	100.0	72	100.0	72	1

This table gives the distribution of different clinical parameters of the study participants: s/d Ratio, Patient Age, Resistance Index (RI), Pulsatility Index (PI), and Hemoglobin levels (Hb_1). Here, 65.3% were within the normal category for s/d Ratio, thus representing stable placental perfusion. Moreover, 44.4% fell in the younger age category. The majority (70.8%) of them had normal RI values, which indicated that vascular conditions were good, although nearly half (48.6%) were classified under moderate PI levels, which is an area that requires clinical intervention.

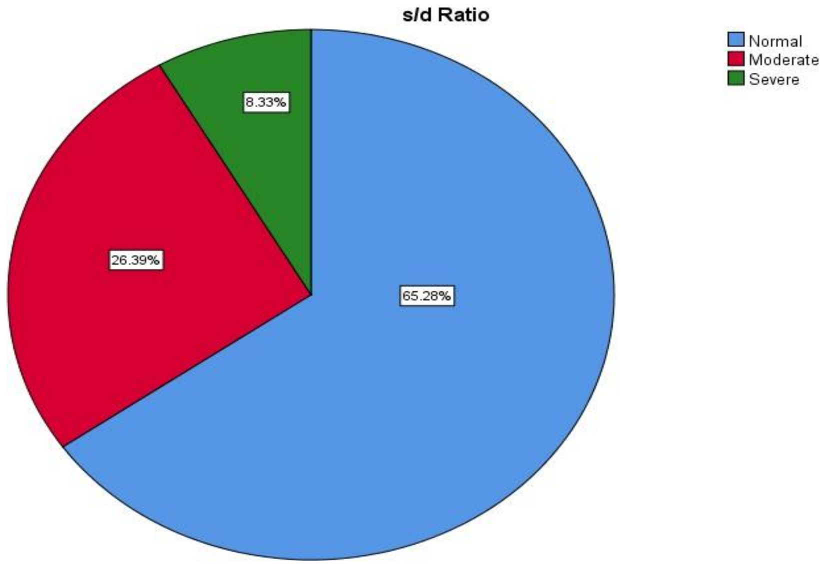

FIGURE 2.1: A Pie-Chart representation of s/d Ratio

Normal Category: Constituting 65.3%, it reflects stable conditions for the majority of patients.

Moderate Category: At 26.4%, this segment signifies patients at potential risk.

Severe Category: Making up 8.3%, this is the critical group requiring immediate attention

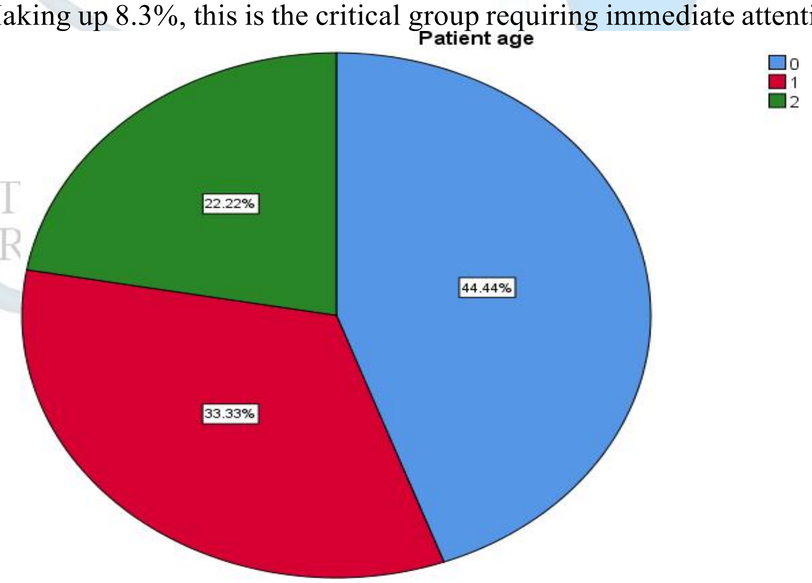

FIGURE 2.2: A Pie-Chart representation of Patient Age

Category 0 (Blue): Constitutes **44.44%** of the dataset, representing the largest single proportion. **Category 1 (Red)**: Accounts for **33.33%** of the patients, indicating a significant portion of the sample. **Category 2 (Green)**: Makes up **22.22%**, the smallest segment in the dataset.

This segmentation suggests a balanced distribution, with **Category 0** being the most prevalent, followed by **Category 1** and **Category 2**. These categories could correspond to specific age ranges or classifications, which should be defined explicitly in the thesis to enhance clarity.

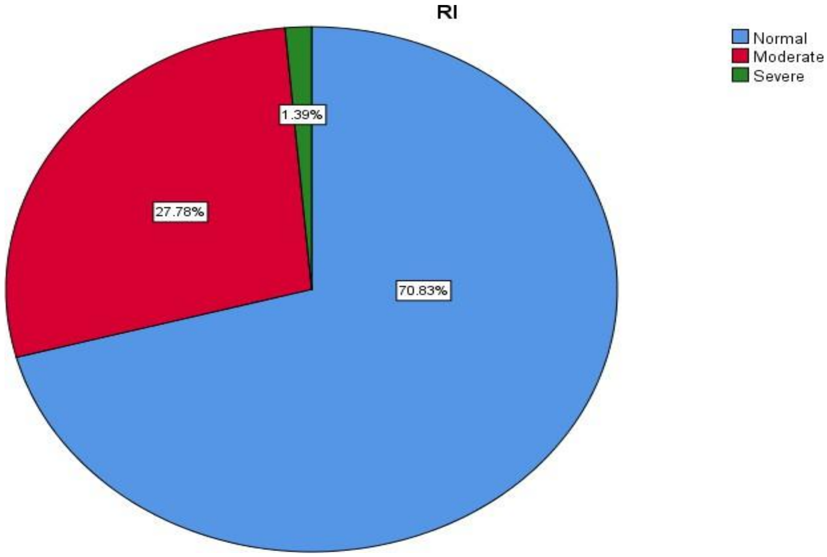

FIGURE 2.3: A Pie-Chart representation of Resistive Index of Umbilical Artery

Normal (70.83%): Represented by the blue section, this category constitutes the majority of the dataset, indicating that a significant portion of the population falls under normal conditions as per the RI measurement.

Moderate (27.78%): The red section of the chart indicates the moderate category, comprising slightly over one-fourth of the total dataset. This suggests a notable prevalence of moderate conditions.

Severe (1.39%): Depicted by the green section, this category accounts for a very small percentage of the dataset. This suggests that severe conditions are relatively rare in the studied population.

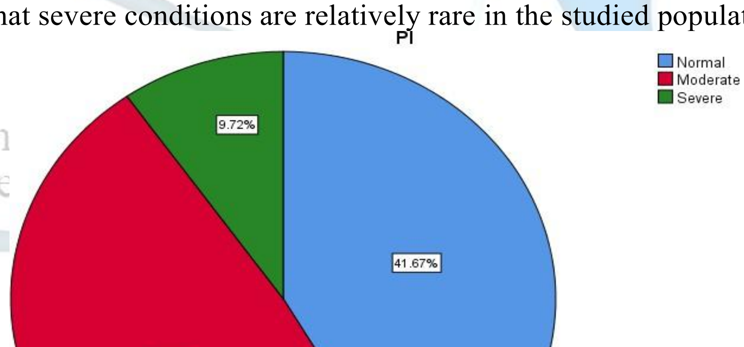

FIGURE 2.4: A Pie-Chart representation of Pulsatility Index of Umbilical Artery Normal PI: Accounting for 41.7%, these cases show standard pulsatility index levels.
Moderate PI: The largest segment at 48.6%, signaling potential concerns in nearly half the population.
Severe PI: Representing 9.7%, it identifies cases with critical PI levels requiring immediate follow-up.

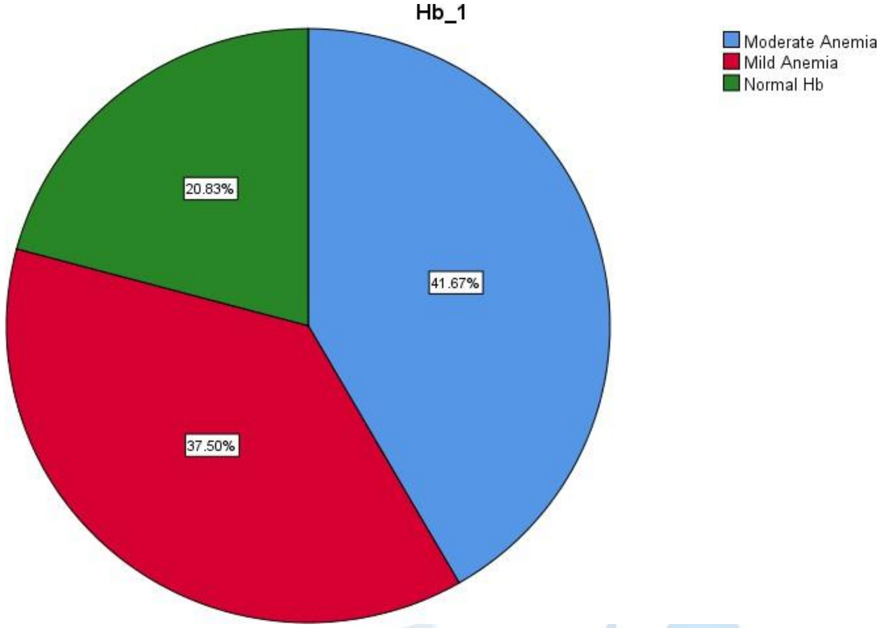

FIGURE 2.5: A Pie-Chart representation of Hb of Patients

Moderate Anemia: Representing 41.7%, this segment forms the largest portion, highlighting its prevalence and the need for targeted interventions.

Mild Anemia: At 37.5%, this group reflects a significant proportion of patients requiring moderate care.

Normal Hb: Comprising 20.8%, this category shows a smaller but healthy subset of the population.

Crosstabs of Hemoglobin Levels and Resistance Index

Crosstab analysis shows that the majority of patients classified with anemia have normal RI, implying that anemia can be present despite apparently normal RBC indices. The Chi-Square tests did not show any association between hemoglobin levels and the categories of RI ($p > 0.05$), and this implies that the observed frequencies are not significantly different from those expected under the null hypothesis. This further supports an investigation into why anemia is somehow sustained despite normal RBC indices, which might influence clinical approaches to the treatment of anemia in pregnant women. Many individuals with all types of anemia reported have a normal RBC index (RI). This may suggest that anemia is present even when RBC indices appear normal. - There are very few cases of severe RI across all categories, indicating that severe anemia is rare among the sampled individuals. - Normal Hb levels are also present in individuals predominantly characterized by a normal RI, indicating that while they possess a normal Hb count, some may still experience mild or moderate anemia.

Crosstab highlights that anemia prevalence (both mild and moderate) is more common among individuals with normal RI, emphasizing the need for further investigation into why these individuals exhibit anemia despite normal RBC indices. This could influence clinical approaches for diagnosing and managing anemia in various populations

Crosstab					
Count					
		RI			Total
		Normal	Moderate	Severe	
Hb_1	Moderate Anemia	21	9	0	30
	Mild Anemia	21	5	1	27

	Normal Hb	9	6	0	15
Total		51	20	1	72

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.795[a]	4	.434

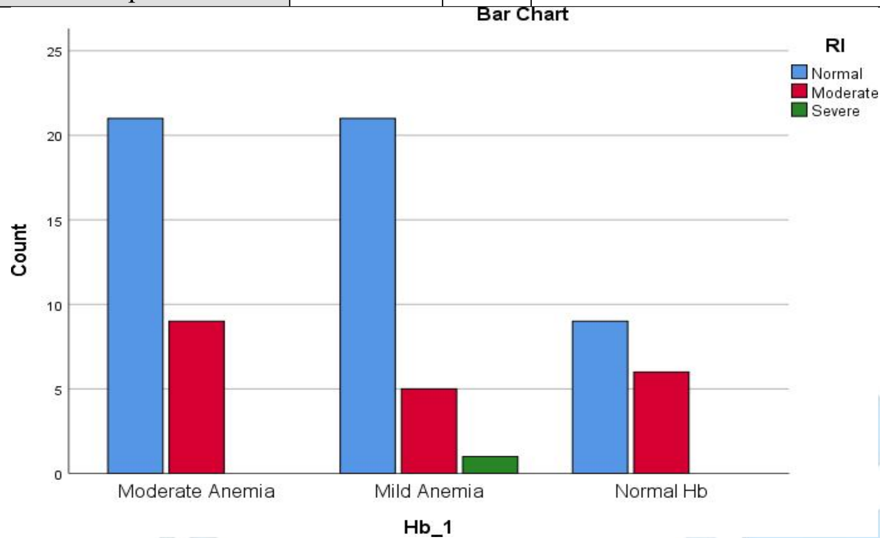

FIGURE 3: A bar chart representation of Data between Hemoglobin levels and RI catogory

The bar chart expresses the relationship of hemoglobin level with RI category, which displays that the predominant category is the Normal RI group in all of the Hb_1 groups, while categories of moderate and severe are comparatively less.

This structured analysis focuses on the most important findings concerning demographic data, within- group distributions, and inter-group relationships regarding the umbilical artery flow patterns in anemic pregnant women, underlining areas of potential clinical focus and further research.

Crosstabs of Hemoglobin Levels and s/d ratio

Crosstab					
Count					
		s/d Ratio			Total
		Normal	Moderate	Severe	
Hb_1	Moderate Anemia	18	7	5	30
	Mild Anemia	19	7	1	27
	Normal Hb	10	5	0	15
Total		47	19	6	72

Chi-Square Tests			
	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.067[a]	4	.281

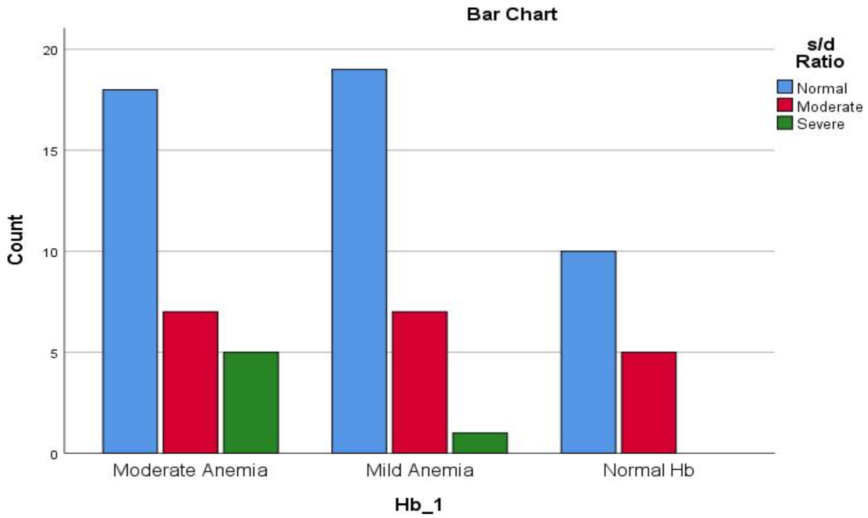

FIGURE 4: A bar chart representation of Data between Hemoglobin levels and s/d Ratio

Crosstab Analysis of Hemoglobin Levels and Pulsatility Index (PI)

Crosstab analysis revealed that Moderate PI was the predominant one among those who had both Moderate Anemia and Mild Anemia, and hence, a relationship between anemia severity and placental perfusion as assessed by PI could be assumed. Results from Chi-Square test showed that hemoglobin level is not associated with PI categories at p-value > 0.05; this means variations in PI are not significantly related to hemoglobin classification in this population.

Crosstab

Count

		PI			Total
		Normal	Moderate	Severe	
Hb_1	Moderate Anemia	12	12	6	30
	Mild Anemia	11	15	1	27
	Normal Hb	7	8	0	15
Total		30	35	7	72

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.634[a]	4	.157

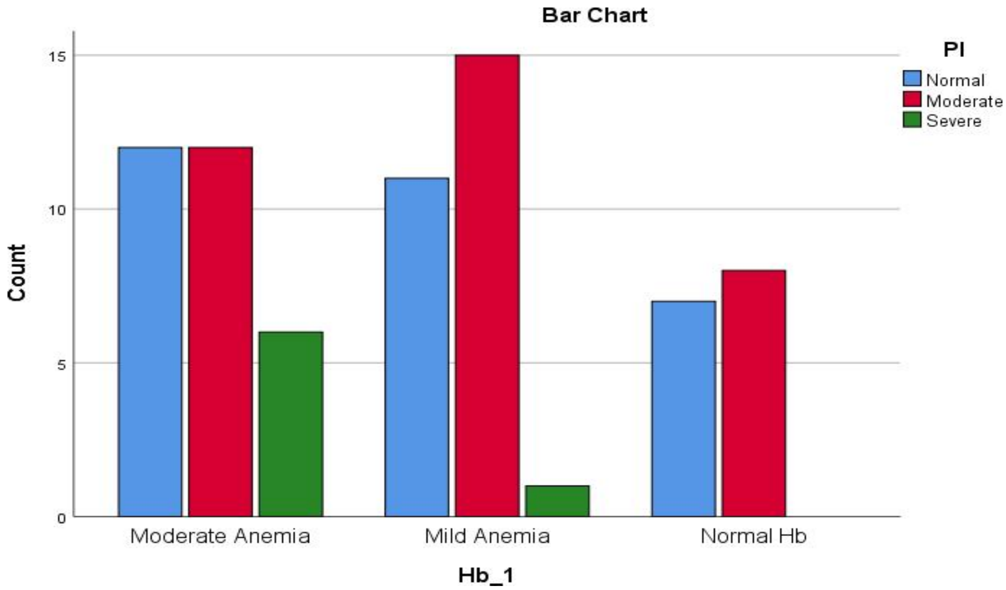

FIGURE 5: A bar chart representation of Data between Hemoglobin levels and PI

This bar chart highlights the distribution patterns of PI categories relative to Hb_1 levels. The Moderate PI category dominates across all groups, while the Severe PI category is rare, indicating that severe placental insufficiency is less common across all hemoglobin levels.

Discussion

The findings of this study offer critical insights into the relationship between anemia, placental perfusion, and umbilical artery Doppler parameters in pregnant women. The mean hemoglobin level of 10.29 g/dL indicates that most participants had mild anemia, aligning with the global prevalence of anemia in pregnancy, which affects approximately 41.8% of pregnant women (World Health Organization, 2021). The average BMI of 26.39 suggests a slightly overweight population, reflecting a trend increasingly seen in obstetric populations due to lifestyle changes. A significant majority of participants (65.3%) exhibited normal systolic/diastolic (S/D) ratios, indicating stable placental perfusion, in line with previous studies (Gramellini et al., 1992), which established a normal S/D ratio as a sign of adequate fetal blood flow and oxygenation. The moderate and severe S/D ratios (26.4% and 8.3%, respectively) observed in the study may suggest early placental insufficiency, which is a recognized complication in pregnancies complicated by anemia (Khalil et al., 2020).The study also found that most participants had normal resistance index (RI) values (70.8%), consistent with earlier research showing that mild anemia does not typically affect umbilical artery vascular resistance (Bhalerao et al., 2012). The rarity of severe RI (1.4%) indicates that significant vascular compromise is uncommon in this population. Nearly half of the participants (48.6%) had moderate pulsatility index (PI) values, which may raise concerns about subclinical placental dysfunction, as moderate PI levels have been linked to increased vascular resistance, possibly preceding overt placental insufficiency (Baschat et al., 2000).Despite these findings, no significant association was found ($p > 0.05$) between hemoglobin levels and RI, S/D ratio, or PI, suggesting that anemia may not directly affect umbilical artery hemodynamics in the majority of cases. This contrasts with studies such as Okonofua et al. (1992), which reported associations between severe anemia and Doppler abnormalities. This suggests that mild to moderate anemia primarily influences systemic parameters rather than directly affecting localized umbilical artery flow. Additionally, a high proportion of participants with normal RI also exhibited anemia, supporting findings by Akingbola et al. (2006), which proposed that systemic factors like nutritional deficiencies, inflammation, or chronic conditions contribute to anemia independent of vascular indices.The prevalence of moderate PI levels among anemic participants mirrors the findings of Arduini et al. (1987), who suggested that PI may be an early indicator of placental dysfunction compared to other Doppler parameters. The high incidence of anemia, even among those with normal RI and S/D ratios, highlights the multifactorial nature of anemia in pregnancy, with studies by Kalaivani (2009) and Stoltzfus et al. (2001) emphasizing the role of nutritional deficiencies and systemic inflammation, which may not directly influence umbilical artery hemodynamics. The moderate PI levels observed in the study suggest that placental compromise might develop even without overt vascular abnormalities, underscoring the importance of early screening and intervention, as advocated by Baschat et al. (2007).This study highlights the necessity of evaluating both systemic and placental factors in the management of anemia during pregnancy. Doppler studies should be combined with biochemical markers such as serum ferritin and transferrin saturation, as well as clinical assessments, to provide a comprehensive understanding of pregnancy health. Overall, the findings contribute to the growing body of evidence on the impact of anemia on placental perfusion, underscoring the importance of early and multifactorial screening. Future research should explore the underlying mechanisms linking anemia with Doppler abnormalities and include larger, more diverse populations, along with longitudinal studies, to assess causal relationships and long-term neonatal outcomes.

Conclusion:

This study highlights the impact of anemia on placental perfusion and fetal hemodynamics, showing that mild to moderate anemia does not significantly affect Doppler indices but may lead to subclinical placental dysfunction. It underscores the importance of early and comprehensive screening for anemia, integrating Doppler studies with nutritional and biochemical assessments.Future research with larger, diverse populations is needed to better understand the relationship between anemia, placental health, and neonatal outcomes.

Limitations and Future Directions:

The study primarily focused on umbilical artery Doppler parameters, without incorporating a more comprehensive evaluation of systemic factors, such as nutritional deficiencies and inflammatory markers, which are known contributors to anemia. The exclusion of certain high-risk groups, such as women with chronic illnesses or multiple pregnancies, may have further narrowed the applicability of the findings. Lastly, the lack of long-term follow-up precludes assessment of enduring maternal and neonatal outcomes, and potential variability in ultrasound equipment and operator expertise may introduce measurement bias. These limitations highlight the need for future research with larger, more diverse cohorts and longitudinal designs to validate and expand upon these findings.

This study primarily focused on the evaluation of the umbilical artery only. While the umbilical artery is a crucial vessel in assessing fetal well-being, the exclusion of other vessels, such as the middle cerebral artery or ductus venosus, may limit the comprehensiveness of the fetal circulation assessment. Future studies could consider multi-vessel Doppler studies to provide a more detailed and accurate evaluation of fetal hemodynamics.

Conflicts of Interest:

We declare that we have no conflicts of interest regarding this research project. This includes financial interests, consulting arrangements, affiliations, or any involvement with organizations that could potentially bias our research.

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