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Assessment Of Placental Stiffness Using Shear Wave Elastography in Pregnancy Induced Hypertension and Gestational Diabetes Mellitus in Comparison with Normal Pregnancy

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Abstract
Introduction: *Pregnancy is a dynamic physiological state that involves complex interactions between the mother, foetus, and placenta. The placenta plays a central role in ensuring optimal fetal development and growth by facilitating the exchange of nutrients, oxygen, and waste products between the maternal and fetal circulations. Its structural and functional integrity is critical for maintaining a healthy pregnancy.[1] Abnormalities of placenta may result in pregnancy-induced hypertension, oligohydramnios, Intra-uterine growth restriction (IUGR) and fetal demise.*
Materials and methods: *After obtaining informed consent and explaining the study objectives, data collection was conducted systematically. Demographic details, including the age of the study participants, were recorded, along with obstetric history and parity status. Clinical parameters such as blood pressure and random blood sugar (RBS) levels were measured. Placental stiffness was assessed using Mindray Resona I9 ultrasound machine equipped with shear wave elastography. The patient was positioned supine, and a grey scale ultrasound was performed to determine gestational age and placental location. Shear wave elastography was conducted during quiet respiration, ensuring that measurements were not taken during fetal movements.*
Results: *Among the total participants, 25 (25%) had pregnancy-induced hypertension (PIH), 25(25%) had gestational diabetes mellitus (GDM), and 50(50%) had normal gestation. The mean age was highest in the PIH group at 25.56 ± 4.538 years, followed by the GDM group (24.88 ± 3.822 years) and the normal gestation group (24.38 ± 3.681 years). However, statistical analysis using both Chi-square and ANOVA tests revealed no significant difference in age distribution among the groups (p-values = 0.191 and 0.474 respectively), indicating that age was not a significantly differentiating factor across the study groups ($p \leq 0.05$).*
Conclusion: *Assessing placental stiffness by shear wave elastography in 2nd and 3rd trimesters helps as an advanced tool to evaluate PIH and gestational diabetes patients, thus helping in early detection and management of placental dysfunction, ultimately improving outcomes for pregnancies affected by PIH and GDM.*
Key Words: *Placenta, Shearwave Elastography, PIH, GDM, PI*

I. INTRODUCTION

Pregnancy is a dynamic physiological state that involves complex interactions between the mother, foetus, and placenta.[1] The placenta plays a central role in ensuring optimal fetal development and growth by facilitating the exchange of nutrients, oxygen, and waste products between the maternal and fetal circulations. Its structural and functional integrity is critical for maintaining a healthy pregnancy.[1] Abnormalities of placenta may result in pregnancy-induced hypertension, oligohydramnios, Intra-uterine growth restriction (IUGR) and fetal demise. At term, placenta is one sixth of the foetus by weight. However, pathological conditions such as

pregnancy-induced hypertension (PIH) and gestational diabetes mellitus (GDM) can significantly alter placental morphology and function, potentially impacting maternal and fetal outcomes.

Pregnancy-induced hypertension (PIH), characterized by elevated blood pressure during pregnancy, is observed in approximately 5-8% of pregnancies globally. Maternal complications associated with PIH include acute renal failure, hepatic dysfunction, postpartum haemorrhage, disseminated intravascular coagulation, placental abruption, and cerebrovascular accidents. For the foetus, complications can include preterm birth, intrauterine growth restriction, stillbirth, and neonatal mortality.[6]

Gestational diabetes mellitus, on the other hand, is a metabolic disorder characterized by glucose intolerance with onset or first recognition during pregnancy. GDM is associated with placental changes, including increased thickness, vascular alterations, and reduced elasticity, which can compromise placental function. These changes may predispose affected pregnancies to complications such as macrosomia, neonatal hypoglycemia, and long-term metabolic disorders in offspring.

A thick placenta is commonly associated with conditions such as gestational diabetes, hydrops fetalis, intrauterine fetal infections, and Rh-negative pregnancies. Conversely, a thin placenta is typically seen in cases of pre-eclampsia and intrauterine growth restriction. As gestation progresses, placental tissue becomes less elastic, undergoing gradual calcification and increased stiffness.

Recent advancements in imaging technology have enabled a non-invasive evaluation of placental properties, providing deeper insights into placental health and disease. Sonoelastography, an imaging modality that measures tissue stiffness, has emerged as a valuable tool for assessing placental elasticity. Placental stiffness, as evaluated by sonoelastography, has been proposed as a potential biomarker for identifying placental dysfunction in various pregnancy complications. It provides quantitative information on the biomechanical properties of the placenta, which may reflect pathological changes associated with PIH and GDM.

This study aims to evaluate placental stiffness using sonoelastography in pregnancies complicated by PIH and GDM, comparing the findings with those of normal gestation. By investigating the correlation between placental stiffness and these conditions, this research seeks to enhance the understanding of placental pathology and its implications for maternal and fetal health. The findings may contribute to the early detection and management of placental dysfunction, ultimately improving outcomes for pregnancies affected by PIH and GDM.

II. AIMS AND OBJECTIVES

AIM OF THE STUDY

• To evaluate placental stiffness by sonoelastography in pregnancy induced hypertension including preeclampsia and gestational diabetes mellitus in correlation with normal gestation.

OBJECTIVES OF THE STUDY

• Routine real time 2D grey scale antenatal ultrasound was performed in all pregnant woman who were referred to the department of radio-diagnosis in their second and third trimester.

• Gestational age of the foetus, placental localization, and placental thickness were noted down.

• Sonoelastography of placenta was performed and stiffness of placenta was noted.

• Mean stiffness of the placenta in pregnancy induced hypertension, preeclampsia and gestational diabetes mellitus was compared with that of the normal gestation.

III. MATERIALS AND METHODS

The present Cross Sectional Observational Study was conducted in the department of radio- diagnosis, Bhaskar Medical College and Hospital, Telangana, India.

STUDY DESIGN: Cross Sectional Observational Study

STUDY DURATION: 18 months (2023 - 2025)

STUDY SETTING: Department of radio-diagnosis, Bhaskar Medical College and Hospital, Telangana, India.

STUDY POPULATION: 100 pregnant women who were referred to the department of radiodiagnosis, Bhaskar medical college and general hospital for antenatal ultrasound scan over a period of 18 months.

INCLUSION CRITERIA:

• Singleton pregnant women with normal gestation, pregnancy induced hypertension (SBP/DBP > 140/90mmHg), preeclampsia and gestational diabetes mellitus (RBS > 200 mg/dl) in their second and third trimester.

• Anterior and lateral placental location.

EXCLUSION CRITERIA:

• Posterior placenta

• Abnormal placental adherence or penetration

• Placental hematoma
• Known case of chronic hypertension
• Known case of diabetes mellitus
● Pregnant women with chronic renal disease or autoimmune disease
• Those who do not give consent for the study.

SAMPLE SIZE: 100 cases for comparative study of placental stiffness.

ETHICAL CLEARANCE: Ethical clearance was obtained from institutional review board of Bhaskar medical college and hospital, Telangana, India.

STUDY METHOD:

After obtaining informed consent and explaining the study objectives, data collection was conducted systematically. Demographic details, including the age of the study participants, were recorded, along with obstetric history ana parity status. Clinical parameters such as blood pressure and random blood sugar (RBS) levels were measured. Placental stiffness was assessed using Mindray Resona I9 ultrasound machine equipped with shear wave elastography. The patient was positioned supine, and a grey scale ultrasound was performed to determine gestational age and placental location. Shear wave elastography was conducted during quiet respiration, ensuring that measurements were not taken during fetal movements. A 10×10 mm Region of Interest (ROI) box was placed on the placenta, and six stiffness measurements were obtained two at the central zone and four at the peripheral zones on both the maternal and fetal sides. Measurements were taken at the superior, centre, and inferior ends of the placenta while avoiding vascular structures and calcifications. The average placental stiffness was calculated and recorded in kiloPascals (kPa). Placental thickness and mean pulsatility index of uterine artery (UA) were also measured.

STATISTICAL ANALYSIS: All collected data were systematically documented, ANOVA and CHI-SQUARE test were performed.

IV. RESULTS AND ANALYSIS

TABLE 1: DISTRIBUTION OF STUDY PARTICIPANTS BASED ON GESTATIONAL CONDITION

VARIABLES	FREQUENCY	PERCENTAGE
PIH	25	25
GDM	25	25
NORMALGESTATION	50	50

GRAPH 1: DISTRIBUTION OF STUDY PARTICIPANTS BASED ON GESTATIONAL CONDITION

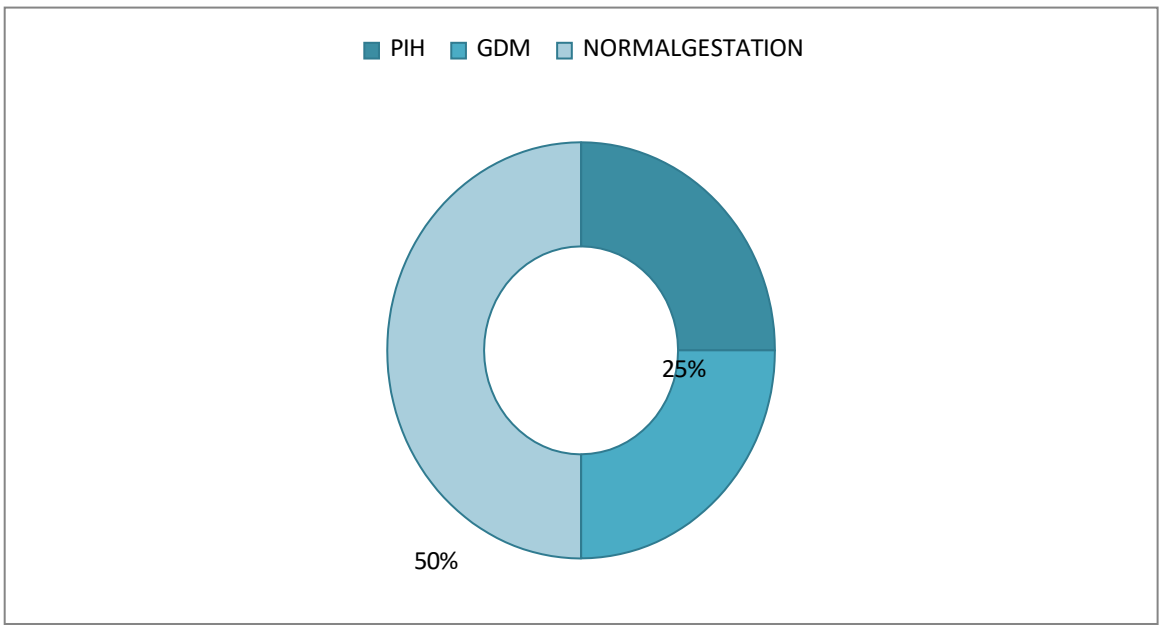

Table 1 and Graph 1 presents the distribution of study participants based on their gestational condition. Among the total participants, 25 (25%) had pregnancy-induced hypertension (PIH), 25(25%) had gestational

diabetes mellitus (GDM), and 50(50%) had normal gestation.

TABLE 2: AGE DISTRIBUTION OF STUDY PARTICIPANTS

Age	PIH		GDM		Normal Gestation		P-Value
	N/MEAN	%/SD	N/MEAN	%/SD	N/MEAN	%/SD	
<20	0	0	3	12	6	12	0.191
20-30	22	88	20	80	43	86	
31-40	3	12	2	8	1	2	
Mean ± SD	25.56±4.538		24.88±3.822		24.38±3.681		0.474

Chi-square; ANOVA, P≤0.05isstatistically significant

GRAPH 2: AGE DISTRIBUTION OF STUDY PARTICIPANTS

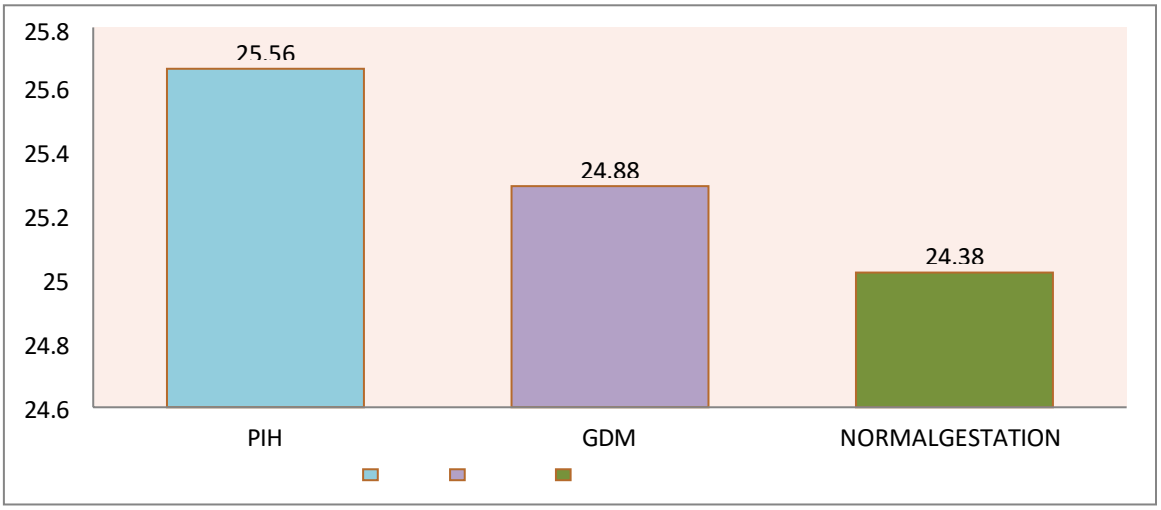

Table 2 and Graph 2 presents the age distribution of study participants. The majority of participants in all groups were between 20 and 30 years of age, comprising 88% of the PIH group, 80% of the GDM group, and 86% of the normal gestation group. A smaller proportion of participants fell into the 31–40 age range, with 12% in the PIH group, 8% in the GDM group, and only 2% among those with normal gestation. Notably, no participants under20 years were recorded in the PIH group, while this age category accounted for 12% in both the GDM and normal gestation groups.

The mean age was highest in the PIH group at 25.56 ± 4.538 years, followed by the GDM group (24.88 ± 3.822 years) and the normal gestation group (24.38 ± 3.681 years). However, statistical analysis using both Chi-square and ANOVA tests revealed no significant difference in age distribution among the groups (p-values = 0.191 and 0.474 respectively), indicating that age was not a significantly differentiating factor across the study groups ($p \leq 0.05$).

TABLE 3: PARITY STATUS AMONG STUDY PARTICIPANTS

PARITY STATUS	PIH		GDM		NORMAL GESTATION		P-VALUE
	N	%	N	%	N	%	
PRIMI	18	72	11	44	28	56	0.001
2nd	2	8	12	48	17	34	
3rd	3	12	2	8	1	2	
4th	0	0	0	0	1	2	
5th	2	8	0	0	3	12	

Chi-square, P≤0.05 is statistically significant

GRAPH 3: PARITY STATUS AMONG STUDY PARTICIPANTS

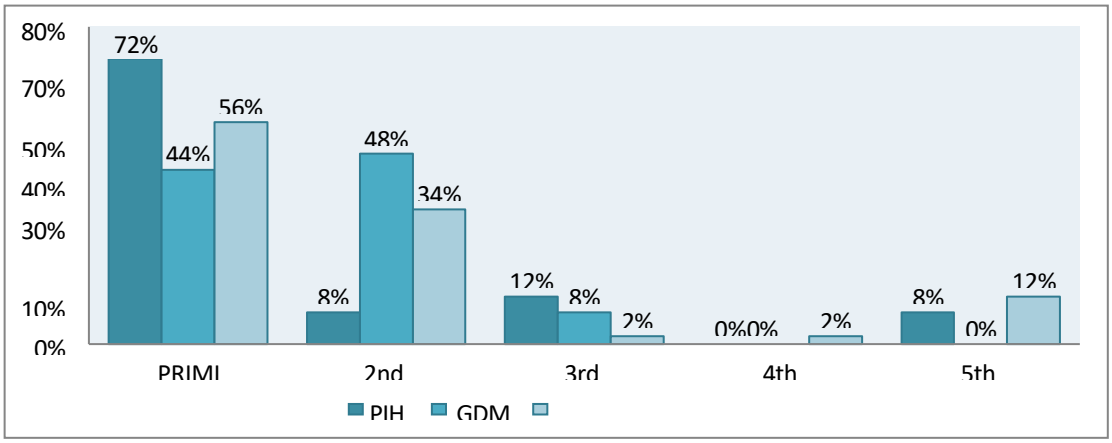

Table 3 and Graph 3 presents the parity status among study participants, showing a statistically significant difference (p = 0.001) across the groups. Primigravida women constituted the majority in the PIH group (72%) compared to 44% in the GDM group and 56% in the normal gestation group. In contrast, second and third parity were more frequent in the GDM and normal gestation groups, with 48% and 34% of second-parity cases, respectively. Higher parity (fourth and fifth) was rare across all groups, with only a small proportion observed in the normal gestation and PIH groups. The findings suggest that primigravida status may be more associated with PIH, whereas higher parity appears more common in normal and GDM pregnancies.

TABLE 4: GESTATIONAL AGE (TRIMESTER) AMONG STUDY PARTICIPANTS

Trimester	PIH		GDM		NORMAL GESTATION		P-VALUE
	N	%	N	%	N	%	
2nd	17	68	18	72	34	68	0.932
3rd	8	32	7	28	16	32	

Chi-square, P≤0.05 is statistically significant

Table 4 presents the gestational age distribution among study participants. In the second trimester, 17 (68%) with PIH, 18 (72%) with GDM, and 34 (68%) with normal gestation were observed. In the third trimester, 8(32%) participants in the PIH group, 7 (28%) in the GDM group, and 16 (32%) in the normal gestation group were recorded. The chi-square test showed no statistically significant difference in gestational age distribution among the groups (p = 0.932).

TABLE 5: SYSTOLIC BLOOD PRESSURE AMONG STUDY PARTICIPANTS

VARIABLES	MEAN	SD	P-VALUE
PIH	150.04	7.887	**<0.001**
GDM	105.84	10.625	
NORMALGESTATION	106.10	10.025	

ANOVA, P≤0.05 is statistically significant

Table 5 presents the systolic blood pressure (SBP) among study participants. The mean SBP was 150.04±7.89 mm Hg in the PIH group, 105.84±10.63 mmHg in the GDM group, and 106.10 ± 10.03 mmHg in the normal gestation group. The ANOVA test showed statistically significant difference in SBP among the groups (p < 0.001).

TABLE 6: DIASTOLIC BLOOD PRESSURE AMONG STUDY PARTICIPANTS

VARIABLES	MEAN	SD	P-VALUE
PIH	92.64	4.386	<0.001
GDM	71.36	6.664	
NORMALGESTATION	68.86	5.488	

ANOVA, P≤0.05 is statistically significant

Table 6 presents the diastolic blood pressure (DBP) among study participants. The mean DBP was 92.64 ± 4.39 mmHg in the PIH group, 71.36 ± 6.66 mmHg in the GDM group, and 68.86±5.49 mmHg in the normal gestation group. The ANOVA test showed a statistically significant difference in DBP among the groups ($p<0.001$).

TABLE 7: RBS AMONG STUDY PARTICIPANTS

VARIABLES	MEAN	SD	P-VALUE
PIH	118.60	18.561	<0.001
GDM	229.40	16.320	
NORMAL GESTATION	100.04	19.757	

ANOVA, P≤0.05 is statistically significant

Table 7 presents the random blood sugar (RBS) levels among study participants. The mean RBS was 118.60±18.56 mg/dL in the PIH group, 229.40± 16.32 mg/dL in the GDM group, and 100.04 ± 19.76 mg/dL in the normal gestation group. The ANOVA test showed a statistically significant difference in RBS levels among the groups ($p < 0.001$).

TABLE 8: PLACENTAL THICKNESS AMONG STUDY PARTICIPANTS

VARIABLES	MEAN	SD	P-VALUE
PIH	25.07	3.740	0.240
GDM	27.24	8.986	
NORMALGESTATION	24.29	7.289	

ANOVA, P≤0.05 is statistically significant

Table 8 presents the mean placental thickness measured across the three study groups. Participants with GDM exhibited the highest mean placental thickness at 27.24 mm (SD = 8.986), followed by those with PIH at 25.07 mm (SD = 3.740), and those with normal gestation showing a mean thickness of 24.29mm (SD=7.289).

TABLE 9: PLACENTAL STIFFNESS AMONG STUDY PARTICIPANTS

VARIABLES	MEAN	SD	P-VALUE
PIH	10.38	0.325	<0.001
GDM	6.88	1.224	
NORMAL GESTATION	5.31	0.315	

ANOVA, P≤0.05 is statistically significant

Table 9 presents the placental stiffness among study participants. The mean placental stiffness was 10.38± 0.325 kPa in the PIH group, 6.88± 1.224 kPa in the GDM group, and 5.31±0.315 kPa in the normal gestation group. The ANOVA test showed a statistically significant difference in placental stiffness among the groups ($p<0.001$).

Both sides. In GDM the maternal side shows a mean value of 7.44 and the fetal side 6.32**,** suggesting moderately increased stiffness compared to normal. In normal gestation**,** the maternal side has a mean value of 5.69**,** and the fetal side 4.95**,** reflecting the lowest and most physiologically appropriate placental stiffness. However maternal side was more compared to fetal side in all the study participants.

TABLE 11: UTERINE ARTERY (UA) MEAN PULSATILITY INDEX AMONG STUDY PARTICIPANTS

VARIABLES	MEAN	SD	P-VALUE
PIH	1.45	0.277	<0.001
GDM	1.00	0.154	
NORMAL GESTATION	1.07	0.255	

ANOVA, P≤0.05 is statistically significant

TABLE 12: CORRELATION BETWEEN GESTATIONAL AGE, MEAN PLACENTAL STIFFNESS, PLACENTAL THICKNESS AND MEAN PULSATILITY INDEX (UA)

Variables	Mean Placental Stiffness	Mean Pulsatility Index (UA)	Placental Thickness
Normal			
Less than 20 weeks	5.25±0.343	1.24±0.165	19.18±1.577
21-30weeks	5.35±0.307	1.05±0.182	24.44±3.105
>30 weeks	5.42±0.239	0.74±0.151	35.70±5.771
PIH			
21-30weeks	10.39±0.325	1.49±0.240	24.22±2.301
>30 weeks	10.33±0.367	1.27±0.425	29.50±6.746
GDM			
Less than 20 weeks	6.37±0.909	1.07±0.094	21.92±1.854
21-30weeks	7.65±0.803	0.82±0.125	38.70±1.240
>30 weeks	8.91±0.540	0.80±0.100	43.86±2.490

V. DISCUSSION

The overall outcome of pregnancy is influenced by multiple factors, including maternal age, general health, nutritional status, pre-existing medical conditions, and pregnancy-related complications such as pregnancy-induced hypertension (PIH) and gestational diabetes mellitus (GDM). This study aimed to examine the correlation between placental stiffness in healthy pregnancies and those complicated by GDM and PIH.[6]

Shear Wave Elastography (SWE), a non-invasive imaging technique for assessing tissue stiffness, offers significant advantages in prenatal care due to its operator-independent nature and ability to provide functional insights beyond conventional B-mode and Doppler ultrasonography. Research by Farah Kasim Najee, Haider N. AL-Tameemi, and Ohmaru et al. demonstrated that women with gestational hypertension exhibited the highest mean SWE values.[7]

Similarly, increased SWE values have been observed in women with gestational diabetes, as reported by Farah Kasim Najee, Haider N. AL-Tameemi, and Yuskel et al., suggesting a possible association between elevated placental stiffness and pathological conditions such as villous immaturity and chorangiosis in diabetic pregnancies. Studies by Farah Kasim Najee, Haider N. AL-Tameemi, and Altunkeser et al. found no significant differences in placental thickness between normal and high-risk pregnancies; however, a strong correlation between increased placental stiffness and high-risk conditions was identified. This relationship may stem from underlying placental abnormalities, such as infarction or inflammation, which are more frequently encountered in preeclampsia and diabetes.[8]

Furthermore, studies by Baghel et al. in India observed that preeclampsia was associated with a reduction in placental thickness (PT). However, conflicting findings were reported by Afrakhteh et al. in Iran and Miwa et al. in Japan, who noted an increase in PT among preeclampsia and PIH patients. They attributed this thickening to placental inflammation induced by PIH, which may contribute to structural changes in the placenta.[9]

In the present study, among the total participants of 100, 25 (25%) had pregnancy- induced hypertension (PIH), 25 (25%) had gestational diabetes mellitus (GDM), and 50 (50%) were of normal gestation.

In the present study, primigravida women comprised the majority of the PIH group (72%), compared to 44% in the GDM group and 56% in the normal gestation group. In contrast, second and third parity were more prevalent in the GDM and normal gestation groups, with 48% and 34% of second-parity cases, respectively. Higher parity (fourth and fifth) was uncommon across all groups, with only a small proportion observed in the normal gestation and PIH groups.

These findings align with those of Peter et al., who reported a significant positive correlation between proteinuria and blood pressure, noting that pre-eclampsia was more frequent in first pregnancies. Similarly, Singh et al. in Sokoto found that primigravida women had a higher risk of developing PIH and pre-eclampsia, and that women with pre-eclampsia often delivered low birth weight infants, whereas normotensive and non-proteinuric PIH pregnancies resulted in normal birth weights. Pegu et al. observed that pre-eclampsia was more common among primigravida women under 24 years of age in their study of 200 pre-eclampsia cases.

These observations suggest that young women with lower parity, particularly primigravida individuals, are at a higher risk of developing hypertension during pregnancy, which can rapidly progress to proteinuria and pre-eclampsia. Moreover, increasing proteinuria levels may contribute to fetal growth restriction during pregnancy, ultimately leading to low birth weight at delivery.

In this study mean systolic blood pressure was 150.04 ± 7.89 mmHg in the PIH group, 105.84 ± 10.63 mmHg in the GDM group, and 106.10 ± 10.03 mmHg in the normal gestation group. The mean diastolic blood pressure was 92.64 ± 4.39 mmHg in the PIH group, 71.36 ± 6.66 mmHg in the GDM group, and 68.86 ± 5.49 mmHg in the normal gestation group. The mean RBS was 118.60 ± 18.56 mg/dL in the PIH group, 229.40 ± 16.32 mg/dL in the GDM group, and 100.04 ± 19.76 mg/dL in the normal gestation group.

In the present study, placental thickness demonstrated a gestational age-dependent increase across all groups. Among normal pregnancies, placental thickness increased progressively, reaching a mean of 35.70 ± 5.771 mm beyond 30 weeks. In the PIH group, the increase was more modest, rising from 24.22 ± 2.301 mm at 21–30 weeks to 29.50 ± 6.746 mm after 30 weeks. In contrast, participants with gestational diabetes mellitus (GDM) exhibited a marked rise in placental thickness, with the highest mean value recorded at 43.86 ± 2.490 mm after 30 weeks.[10]

VI. CONCLUSION

This study demonstrated that in PIH group mean placental stiffness significantly increased. It also showed increased uterine artery mean PI and reduced placental thickness. In GDM group mean placental stiffness was more in comparison to normal gestational group. It also showed increased placental thickness and normal UA mean PI values. Mean placental stiffness was slightly higher on maternal side compared to fetal side in all study participants. Elevated placental stiffness in PIH and GDM serves as a potential prognostic marker, with higher stiffness levels being associated with an increased risk.

These findings emphasize the clinical importance of monitoring placental changes in hypertensive and diabetic pregnancies to enhance maternal and fetal outcomes. Hence, assessing placental stiffness by shear wave elastography in 2nd and 3rd trimesters helps as an advanced tool to evaluate PIH and gestational diabetes patients, thus helping in early detection and management of placental dysfunction, ultimately improving outcomes for pregnancies affected by PIH and GDM.

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