

Sono-elastographic evaluation of Placenta and Its Correlation with Placental Thickness and Uterine Artery Doppler Parameters

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ABSTRACT

Introduction: Placenta is the supplier of nutrients to the developing fetus. Placental health is directly related to the fetal health. The placental thickness and elasticity have direct impact on the fetal birth weight and wellbeing. There are not many studies in India, correlating the placental elasticity with fetal birth weight and wellbeing.

Aim: To correlate the placental thickness, mean uterine artery Pulsatility Index (PI), placental stiffness, gestational weight and birth weight in controls, gestational diabetes and pregnancy-induced hypertensive patients.

Materials and Methods: This exploratory correlative study was performed on 222 pregnant women in the third trimester of pregnancy. The patients in the third trimester, referred to obstetric ultrasonography from January 2017 to June 2018 were included in the study. The thickness of the placenta was measured at the umbilical cord insertion site. Sono-elastography was performed at the centre, superior and inferior ends of the placenta and the average stiffness was recorded. The average gestational age was estimated using standard sonographic techniques. The average gestational age, placental thickness, stiffness on sono-elastography, mean uterine artery pulsatility index and association with gestational diabetes/pregnancy-induced hypertension were correlated and analysed.

Results: The placental thickness ranged between 27-34 mm in the pregnancy-induced hypertension group with mean of 30.36

mm and standard deviation of 1.868. The thickness ranged between 33-51 mm with a mean of 40.75 mm and standard deviation of 4.181 in patients with gestational diabetes. The Pulsatility Index of the uterine arteries ranged between 1.6-2.2 in pregnancy-induced hypertensive patients with a mean of 1.824. In gestational diabetes patients, the uterine artery Pulsatility Index ranged between 0.6-1.1 with a mean of 0.866. The placental stiffness was significantly higher in pregnancy-induced hypertension group with the mean stiffness being 7.233 and standard deviation of 0.7025 as against the stiffness of 2.906 kpa with standard deviation of 0.2923 in controls and 2.838 with standard deviation of 0.3424 in gestational diabetes patients. All the babies with maternal pregnancy-induced hypertension had low birth weight than the controls and the babies of gestational diabetes patients had higher birth weight.

Conclusion: The placentae in patients with gestational diabetes are larger with larger fetuses. The stiffness of the placenta is not affected by gestational diabetes. The placenta and fetus are smaller in pregnancy-induced hypertensive patients. Stiffness of the placenta is increased in pregnancy-induced hypertension. The placental stiffness can be used as an additional prognostic parameter in the outcome of pregnancy-induced hypertension. The higher the stiffness, more are the chances of intrauterine growth restriction and small fetus.

Keywords: Gestational Diabetes, Placental Stiffness, Placental thickness, Pregnancy-induced Hypertension

INTRODUCTION

Placenta is an organ which supplies oxygen and essential nutrients to the developing fetus. Healthy placenta is directly related to a healthy fetus. 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 fetus by weight. Placental thickness is the simplest measurement of its size. The thickness of the placenta can be easily assessed using ultrasonography. It is measured perpendicularly at the level of cord insertion [1].

Thick placenta is observed in gestational diabetes, hydropsfetalis, intra-uterine fetal infections and Rh negative pregnancy. Thin placenta is a feature of pre-eclampsia and intra-uterine growth restriction. With advancing gestational age, the elasticity of placental tissue reduces and the placenta undergoes progressive calcifications with stiffening. Sono-elastography is a technique to assess the stiffness of the placenta [2].

Not many studies are available in India, correlating the placental thickness and stiffness with fetal birth weight. As per the author's knowledge, this is the only study with such correlation in Indian population.

MATERIALS AND METHODS

This exploratory correlative study was performed on 222 pregnant women in the third trimester of pregnancy (>28 weeks till term) from January 2017 to June 2018. Philips IU22 ultrasound scanner was used for the study. The pregnant women were scanned in supine position, using convex transducer of 3-6 MHz frequency in obstetric settings. All the pregnant women with sonographic gestational age of >28 weeks were included in the study. The pregnancies of <28 weeks gestational age on sonography and multiple pregnancies were excluded from the study.

The thickness of the placenta was measured at the umbilical cord insertion site [Table/Fig-1]. The maximum thickness between the uterine margin (Basal plate) and the free margin (Chorionic plate) of the placenta was included between the callipers. Sonoelastography was performed at the centre, superior and inferior ends of the placenta and the average stiffness was recorded [Table/Fig-2]. Normal placental stiffness on elastography was seen in [Table/Fig-3]. Colour doppler evaluation of pulsatility index of the uterine artery was done [Table/Fig-4]. The average gestational age was estimated using standard sonographic techniques. The average gestational age, placental thickness, stiffness on elastography, mean uterine

artery Pulsatility index and association with gestational diabetes/ pregnancy-induced hypertension were correlated and analysed.

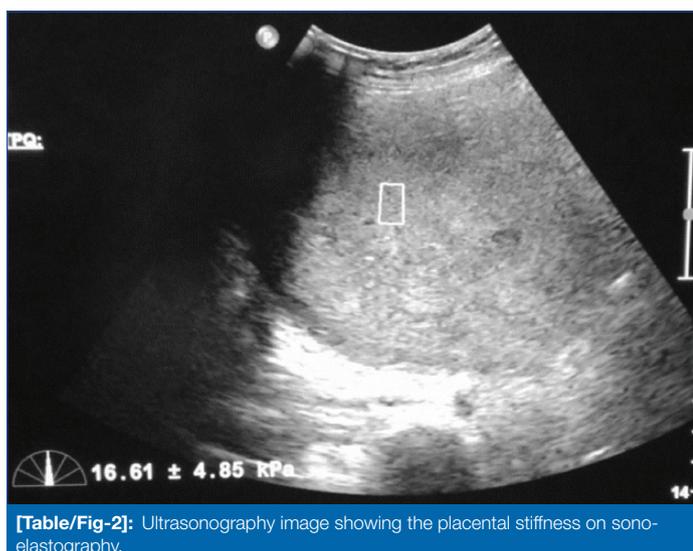
STATISTICAL ANALYSIS

The data were analysed by mean, median, standard deviation and logistic regression using SPSS software version 20.0. Statistical significance was presumed when the p-value was <0.05.



[Table/Fig-1]: Ultrasonography image showing the measurement of placental thickness.

UC: Umbilical cord



[Table/Fig-2]: Ultrasonography image showing the placental stiffness on sono-elastography.

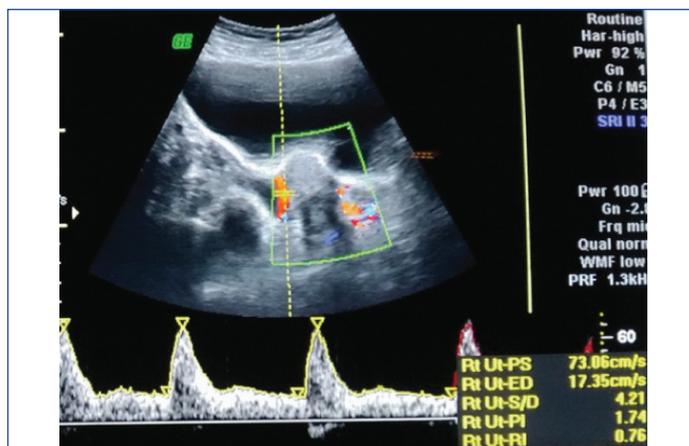


[Table/Fig-3]: Normal placental stiffness on elastography.

RESULTS

Age Wise Distribution of Cases

Two hundred and twenty two patients were included in the study. The patients with pregnancy-induced hypertension were 33 in



[Table/Fig-4]: Colour Doppler evaluation of pulsatility index of the uterine artery.

number 32 patients had gestational diabetes and their age range was 19-40 years. The remaining 157 patients were normal controls with age range of 18-39 years [Table/Fig-5].

Placental Thickness

The placental thickness ranged between 27-34 mm in the pregnancy-induced hypertension group. The minimal placental thickness in pregnancy-induced hypertensive patients was 27 mm and the maximum thickness was 34 mm in the present study. The thickness ranged between 33-51 mm in patients with gestational diabetes. The thickness of the placenta was significantly increased in gestational diabetes patients whereas the placentae were thin in pregnancy-induced hypertension. In the control group, the placental thickness ranged between 30-44 mm with a mean of 35.15 mm [Table/Fig-5].

Mean Pulsatility Index of the Uterine Arteries

The pulsatility index of the uterine arteries ranged between 1.6-2.2 in the pregnancy-induced hypertensive patients. In gestational diabetes patients, the uterine artery pulsatility index ranged between 0.6-1.1. In the control group, it ranged between 0.6-1.2. The placentae were hypermature in all the patients of pregnancy-induced hypertension with the placental grade being Grade III even from 31 weeks of pregnancy. No significant correlation was observed between the placental maturity and gestational diabetes [Table/Fig-5].

Average stiffness of placenta

The mean placental stiffness in control subjects was 2.906 kpa with standard deviation of 0.2923. In patients with gestational diabetes, the mean stiffness was 2.838 kpa with standard deviation of 0.3424. The stiffness was significantly higher in pregnancy-induced hypertension group with the mean stiffness 7.233 kpa and standard deviation of 0.7025 [Table/Fig-5].

Gestational Weight

The gestational weight was significantly lower in the pregnancy-induced hypertension group and higher in the gestational diabetes group [Table/Fig-5].

Birth Weight

The birth weight was significantly higher in gestational diabetes patients and lower in pregnancy-induced hypertensive patients [Table/Fig-5].

DISCUSSION

The general outcome of a pregnancy is dependent on the maternal age, maternal general health, nutrition, coexisting illnesses and presence of pregnancy-related complications like pregnancy-induced hypertension and gestational diabetes. This study was performed to correlate the placental thickness, mean uterine

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Age	0	157	28.20	4.953	0.395	27.42	28.98	18	39
	1	33	28.18	4.599	0.801	26.55	29.81	19	37
	2	32	28.56	5.747	1.016	26.49	30.63	19	40
	Total	222	28.25	5.003	0.336	27.59	28.91	18	40
Thickness	0	157	35.15	3.031	0.242	34.67	35.62	30	44
	1	33	30.36	1.868	0.325	29.70	31.03	27	34
	2	32	40.75	4.181	0.739	39.24	42.26	33	51
	Total	222	35.24	4.171	0.280	34.69	35.79	27	51
Mean PI	0	157	.884	0.1738	0.0139	0.857	0.911	0.6	1.2
	1	33	1.824	0.1678	0.0292	1.765	1.884	1.6	2.2
	2	32	.866	0.1405	0.0248	0.815	0.916	0.6	1.1
	Total	222	1.021	0.3759	0.0252	0.971	1.071	0.6	2.2
Stiffness	0	157	2.906	0.2923	0.0233	2.860	2.952	2.1	3.3
	1	33	7.233	0.7025	0.1223	6.984	7.482	6.2	8.6
	2	32	2.838	0.3424	0.0605	2.714	2.961	2.1	3.4
	Total	222	3.539	1.5945	0.1070	3.328	3.750	2.1	8.6
GW	0	157	2261.78	449.684	35.889	2190.89	2332.67	1150	3200
	1	33	1950.00	274.716	47.822	1852.59	2047.41	1300	2300
	2	32	2493.75	381.159	67.380	2356.33	2631.17	1700	3100
	Total	222	2248.87	442.929	29.727	2190.29	2307.46	1150	3200
BW	0	157	2950.00	165.541	13.212	2923.90	2976.10	2600	3300
	1	33	2403.03	144.665	25.183	2351.73	2454.33	2000	2700
	2	32	3543.75	274.376	48.503	3444.83	3642.67	3100	4150
	Total	222	2954.28	358.658	24.072	2906.84	3001.72	2000	4150

[Table/Fig-5]: Comparison of placental thickness, stiffness, mean uterine artery PI, gestational weight and birth weight in controls, Pregnancy-induced hypertension and Gestational diabetes patients.

(0= Controls; 1=PIH; 2= GDM)

artery PI, placental stiffness, gestational weight and birth weight in controls, gestational diabetes and pregnancy-induced hypertensive patients.

In a normal pregnancy, the placental thickness in millimetres corresponds to gestational age in weeks [3]. Mital P et al., studied the relationship between sonographic placental thickness and the gestational age of the fetus. They found that the placental thickness at the region of insertion of the umbilical cord corresponded exactly with the gestational age as measured by taking Bi-parietal Diameter (BPD), Head Circumference (HC), Abdominal Circumference (AC), and Femur Length (FL) between 22nd-35th week of pregnancy. They concluded that the placental thickness was an important parameter in the estimation of the fetal age in the late mid trimester and early third trimester as the exact duration of pregnancy/ Last Menstrual Period (LMP) was unknown [4]. In our study also, the placental thickness and gestational age showed positive correlation in control subjects.

According to Dambrowski MP et al., placental thickness above 40 mm at term was considered as thick placenta [5]. A thicker placenta is usually associated with gestational diabetes, TORCH infections and hydropsfetalis [6]. In our study, the mean placental thickness in gestational diabetes cohort was above 40 mm and in accordance with the existing literature.

Salmani D et al., conducted a study to observe the morbid changes in the placenta in patients with PIH. They found that the weight and dimensions of the placenta were less in patients with pregnancy-induced hypertension. On histological examination of the placenta, increased number of syncytial knots, fibrinoid necrosis calcification and hyalinization were observed. Proliferation of the tunica media of medium sized blood vessels was also observed. They also observed that mean neonatal birth weight was <2.5 kg in majority of patients with pregnancy-induced hypertension. The fetoplacental weight

ratio was significantly higher than the normal control population [7]. In the present study also, the placentae of pregnancy-induced hypertensive patients were thin and showed hypermature grading for the gestational age. The fetuses and the placentae were smaller as compared to the controls. Small placentae with similar abnormalities were also observed in studies of Silasi M et al., [8].

Hamidi Odessa P et al., conducted a retrospective study to analyse 200 singleton pregnancies by correlating the placental thickness and birth weight. In their study, the mean placental thickness was 34.2±9.7 mm. The strength of correlation between the birth weight and thick placentae was significant [9]. In the present study, also the thicker placentae had high birth weight babies. The thickness and birth weight were directly related to maternal diabetes. The placental thickness and gestational diabetes had positive correlation with statistical significance (p=0.001)

Mean pulsatility index of the uterine arteries is a useful screening parameter for the risk of pregnancy-induced hypertension. In general, uterine artery pulsatility index starts reducing with advancing gestational age. It is never >1.54 after 21 weeks of gestation. The diastolic flow is continuous without any notching in the uterine artery wave form [10]. The upper limit of the reference range is 1.17 after 28 weeks of gestation. In the present study, the mean uterine artery pulsatility index observed was in the range of 1.6-2.2 in patients with pregnancy-induced hypertension. Gomez et al., have observed that progressively increasing pulsatility index of uterine arteries is associated with hypermature placenta and low fetal birth weight [10]. In the present study also, all the patients with high uterine artery pulsatility index showed hypermature placenta and low average birth weight as compared to the controls.

Karaman E et al., studied the stiffness of placenta on sonoelastography in 107 patients. They measured the placental stiffness at three places – fetal edge, maternal edge and central

portion of the placenta. They observed that the placental stiffness was significantly higher in pre-eclampsia patients as compared to normal controls [11]. They also observed that increasing stiffness correlates inversely with the fetal birth weight and placental thickness. The same relation was observed in the present study also. In the present study, the stiffness of the placenta was significantly higher in the pregnancy-induced hypertension group than the control subjects ($p < 0.001$). This increase in placental stiffness in pregnancy-induced hypertension patient's is also in accordance with the study of Kilic F et al., [12]. Similar findings were also observed in the study of Habibi A et al., [13].

No similar comparative study is available in Indian population with comparison of placental elasticity and birth weight. According to the authors' knowledge, this is the only study comparing these parameters in Indian population.

Alan B et al., observed increased incidence of fetal anomalies in patients with increased placental stiffness during the second trimester sonography. However, no such increased incidence of fetal anomalies was detected in the present study [14].

The stiffness of placenta is not affected significantly in patients with gestational diabetes. Bildaci TB et al., did not find any difference in the shear wave elastography values of normal placenta as compared to the placenta of patients with gestational diabetes [15]. In the present study also, the elasticity values of the normal placentae and gestational diabetes placentae were almost similar. No significant increase in stiffness was observed in patients with gestational diabetes.

Pregnancy-induced hypertension results in small for gestational age infants. It is associated with IUGR, low birth weight and intra-uterine fetal demise. Xiong X and Fraser WD, observed that the birth weight difference between infants of pregnancy-induced hypertensive patients and normal mothers was about 460 g [16]. In the present study also, the infants of pregnancy-induced hypertension mothers were smaller than the controls of same gestational age.

Infants of gestational diabetes mothers are known to be larger for the gestational age. Yang Y et al., observed that the blood glucose levels post oral glucose tolerance test were more significant than fasting blood glucose levels in assessing the gestational diabetes. They also observed that infants born to patients with abnormal oral glucose tolerance test values had high incidence of macrosomia [17]. In the present study also, infants of gestational diabetes mothers had higher birth weight and larger placentae.

LIMITATION

Even though the sample size of the controls is adequate, the study may be performed on more number of cases of pregnancy-induced hypertension and gestational diabetes so that the results can be applicable to the general population. This study was only performed in the third trimester. However, there may be a tendency to develop pregnancy-induced hypertension and gestational diabetes in the second trimester itself. Hence, similar study needs to be performed in the second trimester also.

CONCLUSION

Placental thickness is a marker of fetal well being. The placentae are thin in pregnancy-induced hypertension and larger in gestational diabetes. The stiffness of the placenta is increased in pregnancy-induced hypertension due to placental insufficiency. In gestational diabetes, the placental stiffness is not altered. By correlating gestational diabetes and pregnancy-induced hypertension with placental thickness, mean uterine artery pulsatility index and placental stiffness with birth weight, this study provides insight into the changes in microvasculature of the placenta. Placental elastography will act as an adjunct to clinical evaluation and ultrasonography in pregnancy-induced hypertension. Stiffer placentae will result in intra-uterine growth restriction, low birth weight babies and poor pregnancy outcome.

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