RESEARCH ARTICLE

Role of shear wave elastography in assessment of placental elasticity in normal and high-risk pregnancies in third trimester

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Abstract

Objective: To assess the elasticity of placenta using shear wave elastography in normal and high-risk pregnancies in the third trimester.

Method: The prospective, observational study was conducted at the Dow Institute of Radiology, Dow University of Health Sciences, Karachi, from September 15, 2022, to January 15, 2023, and comprised singleton pregnant women during 28-40 weeks of gestation who were referred from the obstetric department. The subjects were divided into normal pregnancy group A and high-risk pregnancy group B. Risk factors include gestational hypertension, gestational diabetes, intrauterine growth restriction, placenta previa, morbidly adherent placenta, old primigravida, teen age and morbid obesity were noted. All the patients underwent grey scale, Doppler ultrasonography and shear wave elastography. Data was analysed using SPSS 26.

Results: Of the 104 subjects, 78(75%) were in group A and 26(25%) were in group B. The overall mean age was 34.2±3.59 years. In group B, mean placental shear wave velocity was 2.34±1.17m/sec and elasticity was 24.41±25.51kPa compared to 1.42±0.55 m/sec and 13.6±10.23kPa in group A (p<0.05). Significant positive correlation was found between shear wave velocity and elasticity values in both groups (p<0.001).

Conclusion: Shear wave elastography was found to be a useful technique in detecting placental stiffness, and can be used as an adjunct to the currently available ultrasonographic methods in high-risk pregnancies.

Keywords: Shear wave, Elastography, Placenta, Velocity, Elastic modulus, High-risk pregnancy. (JPMA 73: 2205; 2023)

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Introduction

Placenta plays an important role in foetal nutrition and oxygenation. It acts as a vector between foetus and mother as it contains both foetal and maternal components. Assessment of placental morphology and functionality is essential antenatally for the monitoring of growth of the foetus. Routinely, it is done by foetal biometric measurements and doppler indices. A high-risk pregnancy is a situation which puts the mother, the foetus, or both, at greater risk than a normal pregnancy. The risk factors include maternal age, hypertension (HTN), diabetes mellitus (DM), renal impairment, hypo- and hyper-thyroidism, morbid obesity, and other diseases.[1]

Elasticity is a physical property and means the ability to regain shape after the deforming force is removed. The tissue stiffness reflects the biological and mechanical properties of tissues and may be affected in conditions like inflammation, fibrosis, or neoplasia.[2] Shear wave elastography (SWE) is a novel technique that provides both qualitative and quantitative assessment of tissue elasticity. Previously, multiple studies have been done to see the SWE role in detecting elasticity of liver, breast, thyroid and lymph nodes (LNs).[3] There are few studies that have been reported in placental tissue assessment.[4] There are limited studies available regarding placental elasticity using SWE worldwide and only 2-3 studies have been conducted in Pakistan to date.[5]

SWE can aid in the detection of placental insufficiency and to increase the diagnostic accuracy of fundamental grey scale and colour Doppler ultrasounds. This can further help in improving diagnostic accuracy of ultrasonography (USG) in detecting placental insufficiency in high-risk pregnancies.

The current study was planned to assess the elasticity of the placenta in normal and high-risk pregnancies in the third trimester.

Patients and Methods

The prospective, observational study was conducted at the Dow Institute of Radiology, Dow University of Health Sciences (DUHS), Karachi, from September 15, 2022, to January 15, 2023. After approval from the institutional ethics review committee, the sample size was calculated using OpenEpi calculator[6] with 95% confidence interval (CI) and 95% power and the case/control ratio of 3:1. Mean

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shear wave velocity (SWV) of placenta in high-risk pregnancies was taken to be 3.85±0.45 and in normal pregnancies 3.38±0.83.[7] The sample was raised using non-probability consecutive sampling technique from among those who were referred from the obstetric department. All singleton pregnant women during 28-40 weeks of gestation were included after taking informed consent from each of the patients. Patients not giving consent, having posterior placental location, patients with already known essential HTN or DM, and those with multiple gestations were excluded.

The subjects were divided into normal pregnancy group A and high-risk pregnancy group B. High-risk pregnancies were considered in pregnant females with the presence of any of the risk factors, including gestational HTN, gestational DM (GDM), intrauterine growth restriction (IUGR) with estimated foetal weight <10th percentile, placenta previa, morbidly adherent placenta, old primigravida aged >35 years, teenage, morbid obesity with body mass index (BMI) >40kg/m^2. Patient's demographic data, parity and gestational age according to last menstrual period or dating obstetric scan were assessed.

All patients underwent routine grey scale USG using convex probe ultrasound machine of Toshiba Aplio 400 by a women imaging radiologist having >5 years of experience and with proper certification in SWE. Assessment of foetal parameters included biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL) and estimated foetal weight. Additional Doppler examination of foetal umbilical and middle cerebral arteries were also performed to evaluate resistive index (RI), pulsitality index (PI) and systolic/diastolic (S/D) ratio.

SWE was performed in the same setting with patients in supine position and during quiet respiration in sagittal imaging plane. To eliminate mechanical artifacts of the probe, excessive gel was applied. A rectangular region of interest (ROI) was used in a fixed dimension of 1.0 x 0.5cm within placenta, devoid of areas of degeneration and calcification. SWV was measured in meter/seconds (m/sec) and elasticity modulus in kilopascals (kPa). The measurements were performed at different depths and sites of placenta. At least 5 readings were measured and the mean value was then taken.

Data was analysed using SPSS 26.

Frequencies and percentages were reported for categorical variables, while mean and standard deviation were reported for continuous variables. The normality of continuous variables was assessed using Shapiro Wilk's test, and the data did not follow normal distribution. As such, median and interquartile ranges (IQR) were also reported. Mann Whitney U-test was used to assess the differences of SWV, kPa, umbilical artery RI, PI, S/D ratio, and middle cerebral artery RI, PI, and S/D ratio between the groups. Mean and standard deviation of SWV, kPa and Doppler indices in high-risk pregnancies were compared to normal pregnancies. Spearman's correlation was used to assess the correlation between placental SWV and kPa in the 2 groups. P<0.05 was considered significant.

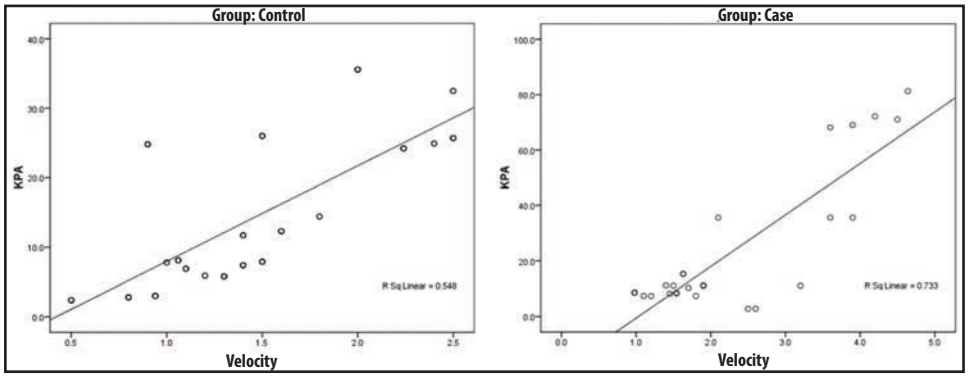
Result

Of the 104 subjects, 78(75%) were in group A and 26(25%) were in group B. The overall mean age was 34.2±3.59 years. Women with IUGR were the largest high-risk subgroup 8(30.7%) patients, followed by gestational hypertension 4(15.4%), placenta previa 3(11.5%), morbidly adherent placenta 3(11.5%), teenage 3(11.5%), GDM 2(7.7%), old primigravida 2(7.7%), and morbid obesity 1(3.8%).

Table-1: Inter-group comparison.

	Group A Mean±SD	**Group B** Mean±SD	***p*-value**
SWV (m/sec)	1.42±0.55	2.34±1.17	<0.001
kPa	13.60±10.23	24.41±25.51	<0.049
U.RI	0.52±0.09	0.57±0.09	0.074
U.PI	0.88±0.16	0.91±0.19	0.171
U.SD	2.42±0.45	2.71±0.48	0.018
M.RI	0.79±0.33	0.72±0.11	0.32
M.PI	1.26±0.22	1.22±0.22	0.23
M.SD	3.82±0.54	4.14±1.49	0.904

SWV: Shear wave velocity, kPa: Kilopascals, U.RI: Umbilical artery resistive index, U.PI: Umbilical artery pulsitality index, U.S/D: Umbilical artery systolic/diastolic ratio, M.RI: Middle cerebral artery resistive index, M.PI: Middle cerebral artery pulsitality index, M.S/D: Middle cerebral artery systolic/diastolic ratio, SD: Standard deviation.



1(A) Group A 1(B) Group B

Figure: Correlation between placental shear wave velocity (SWV) and elastic modulus (kilopascals [kPa]) in groups A and B.

Table-2: Shear wave velocity, elastic modulus (kilopascals) and Doppler indices in pregnant women with high-risk pregnancies.

	kPa	SWV	U.RI	U.PI	U.S/D	M.RI	M.PI	M.S/D
Gestational HTN	70.0±1.82	4.05±0.38	0.57± 0.05	1.02±0.09	2.87±0.09	0.77±0.05	1.15±0.05	3.82±0.37
Gestational DM	9.8±1.97	1.72±0.25	0.55±0.07	0.79±0.13	2.88±0.00	0.70±0.14	1.25±0.21	4.30±0.28
Placenta Previa	10.03±0.56	1.31±0.28	0.48±0.01	0.65±0.04	1.92±0.06	0.73±0.11	1.53±0.30	5.83±2.66
Morbidly adherent placenta	10.36±4.30	1.65±0.13	0.52±0.06	0.74±0.13	2.19±0.43	0.73±0.11	1.46±0.30	5.70±2.77
IUGR	26.98±26.31	3.05±0.94	0.68±0.01	1.08±0.09	3.11±0.32	0.70±0.11	1.08±0.08	3.48±0.61
Teenage	8.46±0.23	1.13±0.27	0.43±0.05	0.86±0.20	2.60±0.36	0.83±0.11	1.30±0.00	3.60±0.00
Old Primigravida	11.15±0.07	1.45±0.07	0.60±0.14	0.95±0.35	3.00±0.28	0.60±0.00	1.05±0.07	3.55±1.34

HTN: Hypertension, DM: Diabetes mellitus, IUGR: Intrauterine growth restriction, kPa: Kilopascals, SWV: Shear wave velocity, U.RI: Umbilical artery resistive index, U.PI: Umbilical artery pulsitality index, U.S/D: Umbilical artery systolic/diastolic ratio, M.RI: Middle cerebral artery resistive index, M.PI: Middle cerebral artery pulsitality index, M.S/D: Middle cerebral artery systolic/diastolic ratio.

In group B, mean placental shear wave velocity was 2.34±1.17m/sec and elasticity was 24.41±25.51kPa compared to 1.42±0.55 m/sec and 13.6±10.23kPa in group A (p<0.05). Median SWV and elasticity values also showed significant difference in both groups (Table 1).

The umbilical artery and middle cerebral artery Doppler indices showed significant positive correlation between placental SWV and elasticity in group A (rs=0.763, p<0.001) and group B (rs=0.644, p<0.001) (Figure A-B).

Among group B patients, mean SWV and elasticity values were highest in patients with gestational hypertension, followed by those with IUGR, while mean values were also high in patients with GDM, morbid obesity and morbidly adherent placenta (Table 2).

Discussion

SWE is a non-invasive method to quantify tissue stiffness. It works on the principle of generation of shear waves by ultrasound beam and prompt imaging of these shear waves. The propagation of SWV in placenta is converted into tissue stiffness in Young's modulus, which is measured in kPa.[8] Due to recent advancements in elastographic techniques, an increasing number of new studies have shown the difference in elasticity of placenta in normal and high-risk pregnancies. Different studies[9] have reported increased stiffness of placenta in different pathological conditions than in normal pregnant women.

To our knowledge, the current study is the first in Pakistan to evaluate SWE of placenta in normal pregnant women and in pregnant women with all the possible high-risk factors in their third trimester. Earlier, a few studies were conducted evaluating placental elasticity in separate individual high-risk factors.[5,10]

The current results showed significant difference in placental SWV and kPa values of normal and high-risk pregnancies. Hafeda and Zakaria[2] showed SWV of 0.85m/s and 0.89m/s in normal pregnancies in their second and third trimester, respectively, compared to 1.42 in the current study. Khanal et al.[11] showed higher SWV in the control group of 3.38m/sec. The mean kPa value in the current study was 13.6 in normal and 24.4 in high-risk pregnancy. Li et al.[12] showed average elastic modulus of 7.6kPa for placental edge and 7.84kPa for central part of placenta in normal pregnant women, which is slightly lower than the current results. Hatice Habibi HA et al.[13] showed higher median values of elastic modulus of 28kPa and 21.5kPa from central and maternal surfaces of placenta in IUGR group, whereas 6kPa and 5.35kPa were reported for the control group, which is in concordance with the current study. A study[14] found a cut-off value of 3.86kPa to differentiate between healthy and malfunctioning placentation with a sensitivity of 86% and specificity of 56%.

Gestational hypertension is a major cause of both foetal and maternal morbidity and mortality. A study showed mean SWV 1.23m/sec in gestational hypertension and 2.23m/sec in preeclampsia/eclampsia with a cut-off value of 1.35m/sec.[2] Sugitani et al.[15] observed higher SWVs in hypertensive patients. Fujita et al.[16] described a cut-off value of 1.18m/sec for preeclampsia. The current study showed the highest values in gestational hypertension women, with mean SWV 4.05±0.38.

Histological changes in placenta and increased placental thickness in GDM lead to increase in elasticity values. In the current study, a significant difference in SWVs was seen in pregnant women with GDM and with morbid obesity than in women with normal pregnancies who had mean SWV 1.7±0.25. Yuksel et al.[17] also observed increased elasticity values in GDM patients. However, Hafeda and Zakaria[2] found no significant difference in SWV values. Old primigravida and teenage pregnant females showed no significant difference in placental SWVs.

Abnormal placental location, like placenta previa and morbidly adherent placenta, is an important risk factor in maternal and foetal morbidity and mortality. The risk further increases with history of previous caesarean section (CS), myomectomy, curettage and with multiparity. Routinely, Doppler USG is used to assess morbidly adherent placenta with a sensitivity of 97%. Occasionally, in some

cases, magnetic resonance imaging (MRI) can be used.18 The current study saw no significant difference in SWE in patients with placenta previa, but increased values were observed in pregnant women with morbidly adherent placenta.

Different studies[10,11,13,14] have shown increased SWVs in placenta of IUGR cases, but no study has to been done yet to detect IUGR earlier than the available routine investigations. Khanal et al.[11] described a cut-off value of 1.28m/sec in IUGR cases. However, more studies are needed in this regard to establish a cut-off point to detect IUGR early and accurately.

The current study has some limitations. It was a single-centre study with a small sample size. Hence, the findings may not accurately reflect the general population. Therefore, multicentre studies with larger sample size are required to validate the findings. Also, the study did not investigate posterior placenta cases as they were excluded. Morphological features of placenta, like grading, placental thickness and presence of calcification, were also not studied. Histopathological correlation of the changes occurring in placenta in normal and high-risk pregnancies was also not compared.

Conclusion

SWE was found to be a relatively new and useful technique in detecting placental stiffness with significant positive correlation. It can be used as an adjunct to the currently available USG methods in high-risk pregnancies to further increase the effectiveness of USG and to reduce the maternal and foetal morbidity and mortality.

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