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Evaluation of placental stiffness in normal versus high risk pregnancy using shear wave elastography

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Abstract

Background: Ultrasound is essential for assessing normal and high-risk pregnancies. A unique ultrasonographic method, shear wave elastography (SWE), measures soft tissue component elasticity. This approach has been used in obstetrics lately. This research uses SWE to assess placental stiffness in healthy and high-risk pregnant women.

Method: The Ultrasound clinic of Al-Zahraa teaching hospital in Al-Najaf governorate performed a case-control research of 100 singleton pregnant women (40 cases and 60 controls) from October to December 2022. Cases were pregnant referred from obstetric clinics with gestational hypertension or diabetes, whereas 60 controls were healthy pregnant with no clinical or sonographic signs of high risk. All cases and controls were 2nd or 3rd trimesters. All patients had B-mode ultrasonography and placental SWE exams, and SPSS was used to analyze the data.

Results: There was a significant difference in mean placental SWE values between studied groups, with the highest means found in pregnant with gestational hypertension (2.05 m/s) and gestational diabetes (1.5 m/s) and the lowest mean found in normal pregnant (1.1 m/s), with a cut-off value of 1.27 m/s to distinguish normal and abnormal placenta In high-risk pregnant women, placental thickness, amniotic fluid index, and stiffness were positively correlated.

Conclusion: Normal pregnancy had less placental stiffness than high-risk pregnancy (hypertension and diabetes). Thus, SWE technology may quantify placenta morphological disorders in hazardous pregnant women.

Keywords: Placenta, gestational diabetes, gestational hypertension, shear wave elastography

Introduction

The placenta is vital for fetal and maternal health and affects long-term wellbeing. Research into its development is challenged by ethical concerns, limited *in vitro* models, and species diversity [1, 2]. Ultrasound, a non-ionizing modality, is standard for imaging the placenta, identifying its echogenicity, and distinguishing normal features from pathologies like hematoma [3]. Recent imaging advancements include elastography, which measures tissue elasticity and is used in assessing organ health with both ultrasound (US) and magnetic resonance (MR) imaging [4]. Ultrasound elastography techniques are categorized by the physical quantity measured: strain imaging, including Strain elastography (SE) and Acoustic Radiation Force Impulse (ARFI) imaging, and Shear Wave Imaging (SWI), which includes transient, point, and two-dimensional methods [4]. *In vivo* and *ex vivo* studies show variable placental elasticity due to different technologies used. High reliability of *in vivo* measurements has been reported, with consistent Shear Wave Velocity (SWV) values across studies using similar systems [5-7]. Factors affecting measurement quality include sample depth and transducer pressure, which may be mitigated by standardized protocols [8-10]. There's limited consensus on normal elasticity at specific gestational stages, and current research shows little significant change in SWV with advancing gestational age [11, 12]. Regional elasticity within the placenta appears consistent across various studies, although some report variability [13, 14]. Confounders like maternal age, blood pressure, and BMI need further investigation [15]. One study suggests increased elasticity with higher BMI, but its reliability is questionable due to large SWV variations [16]. Elastography has been used to study conditions like gestational diabetes, showing higher mean shear values compared to normal controls [14]. Safety concerns for elastography in pregnancy focus on potential tissue displacement effects from radiation force pulses [17, 18]. No placental histological changes have been reported after ARFI imaging [5].

While elastography uses higher thermal indices, they are within safety limits set by the AIUM [19]. Professional bodies like the BMUS and WFUMB endorse the safety of these methods but call for more research to uphold the ALARA principle [20]. The aim of study is to measure the placental stiffness in normal and risky pregnancy using the SWE technique and to assess the factors affecting placental stiffness.

Method

A case control study. The data collection was conducted between the first of October to the end of December of 2022 among pregnant women attending the ultrasound clinic in Al-Zahraa teaching hospital in Al- Najaf governorate. We used a sequential sample throughout data gathering. This research recruited second- and third-trimester singleton pregnant women referred by Obstetric clinics to ultrasonography clinics. This research comprised 60 singleton pregnant women with clinically normal and 40 with clinically hazardous pregnancies. This study aimed to evaluate the use of elastography, a technique that measures the stiffness of tissue, in the context of prenatal care. Participants were selected based on stringent criteria: Those with normal physical examinations, laboratory tests, and ultrasound (US) results were categorized as normal pregnant women, while those with histories of gestational diabetes mellitus (DM) and gestational hypertension were considered high-risk. Exclusion criteria were extensive, filtering out pregnancies complicated by fetal congenital anomalies, significant maternal pathologies, placentas with challenging locations or abnormalities, severe maternal anemia, heart disease, or other significant diseases. The research gathered participant data via a two-part questionnaire that included elastography readings, US results, age, and obstetric history. Using a convex transducer, an advanced GE LOGIC E9 XDClear system was used to do ultrasound examinations. Shear wave elastography (SWE) was used to quantify placental stiffness in these assessments in addition to traditional B-mode imaging, which was used to record foetal and placental parameters such as biparietal diameter, femur length, amniotic fluid index, placental location, thickness, and structure. Certain precautions made sure that the patient's respiration and movement did not interfere too much with SWE. In order to determine the velocity values coded S1 through S4 and P, respectively, the placenta was separated into areas and many measurements were made at various locations, including the maternal surface, central portion, foetal surface, and peripheral placenta. Using ANOVA and T-tests for continuous variables, correlation tests for continuous variable connections, chi-square tests for categorical variable associations, and descriptive statistics were used to analyze the data from these measures using SPSS software. With coefficients ranging from mild (0.2-0.29) to extremely high (≥0.7), the correlation strength was assessed. The Receiver Operating Characteristic (ROC) curve was used to evaluate the elastography test's accuracy; areas under the curve classified the test's diagnostic accuracy from excellent to fail. For statistical significance, a P-value of 0.05 or less was used. The rigorous methodology and detailed data collection aimed to establish the reliability and diagnostic utility of elastography in monitoring placental health and potential risks in pregnancy.

Results

A total of 100 pregnant women were enrolled in this study, 60 women with no risk factors and 40 women with risk factor (20 women with gestational diabetic mellitus and 20 women with gestational hypertension). The age distribution between two group were shown in table 1 and the two groups was homogenous regard age ($p>0.05$).

Table 1: Age Distribution between two studied groups.

Variables		Participants		P value
		Normal pregnancy	Risky pregnancy	
Age	< 20 years	6 (10%)	0	0.058*
	20-30 years	31 (51.7%)	18 (45%)	
	>30 years	23 (38.3%)	22 (55%)	
	Mean ±SD	27±6.2	31±5.8	
Total		60 (100%)	40 (100%)	

*Chi-Square test, significant ≤0.05.

The obstetric history of studied participants shown that 40% (24) of normal pregnancy women and 62.5% (25) of risky pregnant women had more than four gravidities and there was a significant difference in gravidity and parity between two studied group ($p\leq0.05$) and there was no significant difference in abortion history between two group (p= 0.79), table 2.

Table 2: Obstetrical history between studied groups.

Variables		Participants		P value
		Normal pregnancy	Risky pregnancy	
Gravidity	Pimi	7 (11.7%)	0	0.02*
	2-4	29 (48.3%)	15 (37.5%)	
	>4	24 (40%)	25 (62.5%)	
Parity	Nil parity	10 (16.7%)	0	0.008*
	1-3	34 (56.7%)	21 (52.5%)	
	>3	16 (26.7%)	19 (47.5%)	
Abortion	0	34 (56.7%)	20 (50%)	0.79*
	1-3	25 (41.7%)	19 (47.5%)	
	>3	1 (1.7%)	1 (2.5%)	
Total		60 (100%)	40 (100%)	

*Chi-Square test, significant ≤0.05.

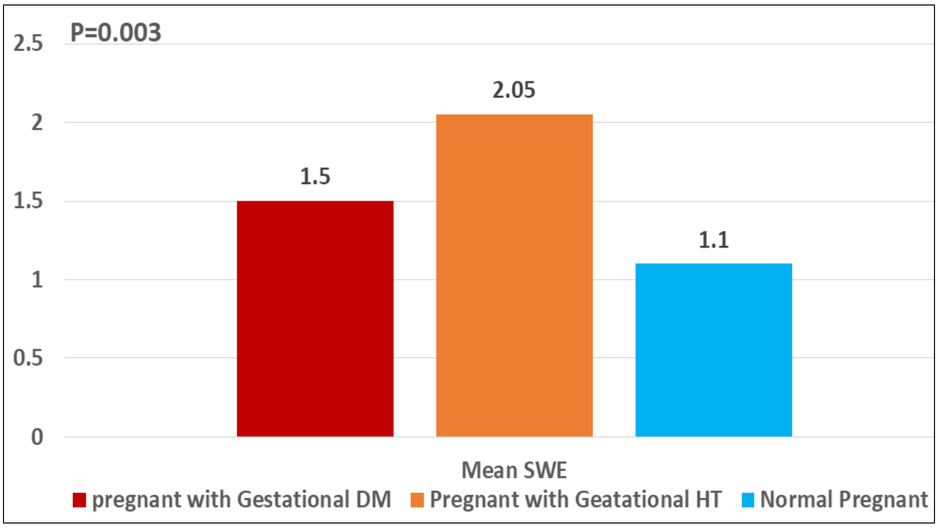
There was no significant difference in the placental thickness, gestational age and amniotic fluid index between two studied group (p>0.05). Polyhydromenous was found in risky pregnancy only (15%) and 35% of risky pregnancy and 21.7% of normal pregnancy had oligohydromenous with a significant difference in the amount of liquor between two studied groups (p=0.001), table 3.

Table 3: Ultrasound finding among two groups.

Ultrasound finding		Participants		P value
		Normal pregnancy	Risky pregnancy	
Placental thickness (Mean± SD)		3.6 ±0.75	3.7± 0.72	0.669*
Gestational age	BPD (Mean± SD)	231± 38	240 ±24	0.21*
	FL (Mean± SD)	238± 36	242 ±25	0.52*
Amount of liquor	Normal	47 (78.3%)	20 (50%)	0.001**
	Oligohydromenous	13 (21.7%)	14(35%)	
	Polyhydromenous	0	6(15%)	
AFI (Mean± SD)		15.3 ±4.1	16 ±6.7	0.56*

*Student T test, **Chi-Square test, significant ≤0.05.

There was a significant difference in the mean SWE between studied groups, were the highest mean was found among pregnant with gestational hypertension and lowest mean was found among normal pregnant (p=0.003), figure 1.



*Student T test, significant ≤0.05.

Fig 1: Difference in the mean SWE between two studied groups

Among normal pregnant women. There was no significant correlation between SWE and age of pregnant women and obstetric history (p>0.05), table 4.

Table 4: Correlation between age and obstetric history with SWE in normal pregnant women.

Variables	SWE	P value
	Correlation coefficient	
Age	0.21	0.87*
Gravidity	0.1	0.41*
Parity	0.5	0.67*
Abortion	0.17	0.19*

Significant ≤0.05.

There was no significant correlation between SWE and ultrasound finding regard placental thickness, BPD, FL and AFI (p>0.05), table 5.

Table 5: Correlation between ultrasound finding and SWE among normal pregnant women

Variables	SWE	P value
	Correlation coefficient	
Placental thickness	-0.18	0.155*
BPD	-0.038	0.78*
FL	0.052	0.71*
AFI	-0.11	0.37*

Significant ≤0.05.

Among the risky women. There was no significant correlation between age, gravidity and parity with SWE, but there was moderate positive correlation between number of abortion and SWE (r=0.32, p=0.039), table 6.

Table 6: Correlation between age and obstetric history with SWE in risky pregnant women.

Variables	SWE	P value
	Correlation coefficient	
Age	-0.34	0.053*
Gravidity	0.22	0.169*
Parity	-0.6	0.7*
Abortion	0.32	0.039*

Significant ≤0.05.

There was a significant strong positive correlation between placental thickness, Amniotic fluid index and SWE (r= 0.49, 0.59. p=0.001, <0.001 respectively), while there was no significant correlation between BPD and FL and SWE (*p*>0.05), table 7.

Table 7: Correlation between Ultrasound finding and SWE in risky pregnant women.

Variables	SWE	P value
	Correlation coefficient	
Placental thickness	0.49	0.001*
BPD	-0.25	0.166*
FL	-0.27	0.14*
AFI	0.59	<0.001*

Significant ≤0.05.

ROC cure and analysis shown that the area under the curve was 0.83 with P value <0.001, the SWE test was good to regard as diagnostic test for risky pregnancy, with The cutoff value maximizing the accuracy of diagnosis was 1.27 m/s, sensitivity, specificity of this cutoff value were 82.5%, 67% respectively, Fig 2.

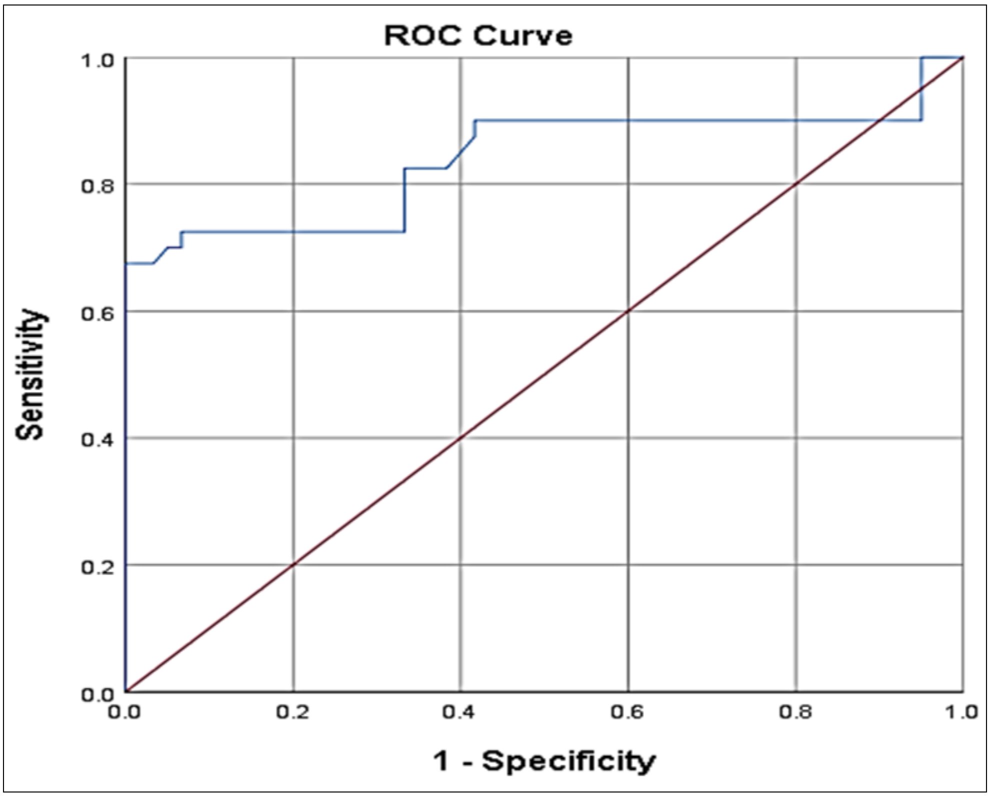


Fig 2: ROC curve for Placental SWE values showing cut of value 1.27 m/s with sensitivity of 82% and specificity

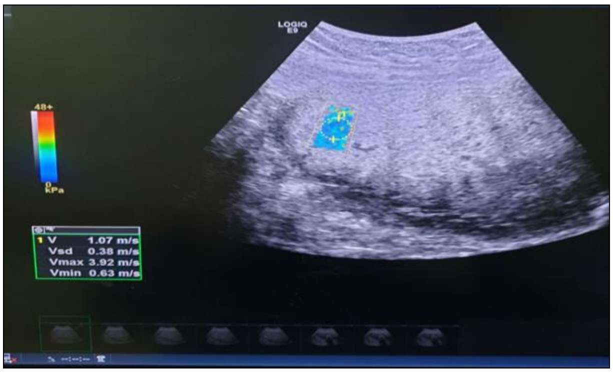


Fig 3: 30 Years' pregnant patient, gestational age about 30 weeks, placental thickness 3.8cm, ROI is placed in the center of colored area with velocity value measured as 1.07 m/s

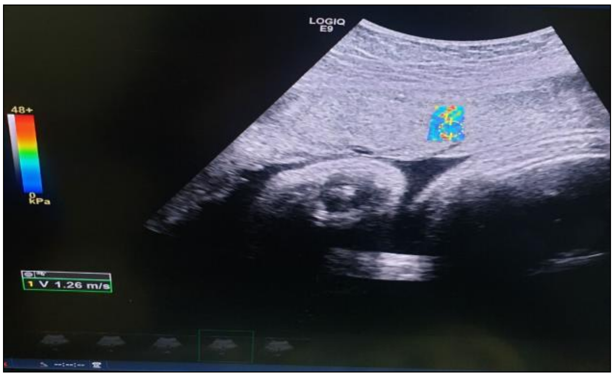


Fig 4: 35 Years old patient with gestational DM, gestational age about 34weeks, placental thickness 3.7cm, ROI is placed in the center of colored area with velocity value 1.26 m/s

Discussion

Shear Wave Elastography (SWE), a non-invasive method assessing tissue stiffness, is advantageous in prenatal care due to its non-operator dependency and ability to provide additional functional information compared to B-mode and Doppler ultrasonography. While Doppler US has been utilized to predict preeclampsia by inspecting uterine artery notches and pulsatility index, SWE offers another dimension by measuring placental stiffness-a marker less studied but potentially indicative of pathology. This study is pioneering in using SWE to assess placental elasticity during the second and third trimesters of pregnancy. It found that women with gestational hypertension presented with the highest mean SWE values, corroborating Ohmaru *et al.*'s findings [6]. Similarly, women with gestational diabetes also showed higher mean SWE values, aligning with results from Yuskel *et al.* [14], suggesting that placental stiffness could be linked to specific pathologies like villous immaturity and chorangiosis observed in diabetic pregnancies. Although placental thickness didn't differ significantly between normal and high-risk pregnancies, a strong correlation with SWE was observed in high-risk cases, supporting findings by Altunkeser *et al.* [21]. This might be due to underlying conditions such as placental infarction or inflammation, more common in preeclampsia and diabetes. The study also reported a positive correlation between amniotic fluid index (AFI) and SWE in high-risk pregnancies, a finding that resonates with Khanal *et al.* [22] and Edward *et al.* [23]. However, no significant correlation between SWE values with maternal age or obstetric history was found, which is consistent with previous research [21]. For the identification of high-risk pregnancies, a cutoff value of 1.27 m/s was determined with sensitivity and specificity rates of 82.5% and 67%, respectively. Due to the low specificity, there's a risk of false positives; hence, additional testing, such as uterine artery Doppler flow velocimetry, could be employed for confirmation. Other studies, like Hefeda *et al.* [24] and Fujita *et al.* [25], found different cutoff values for predicting complications, which may be due to varied inclusion criteria and gestational age at examination.

Conclusion

SWE has shown to be a valuable diagnostic method for assessing placental health, especially in pregnancies at risk. It was observed that the mean SWE values were markedly higher in those with gestational hypertension compared to normal pregnancies. Additionally, a strong correlation was found between SWE, placental thickness, and amniotic fluid index in pregnancies deemed high-risk. For diagnosing such at-risk pregnancies, an SWE cutoff value of 1.27 m/s was determined to be most accurate, yielding a sensitivity of 82.5% and a specificity of 67%.

Conflict of Interest

Not available

Financial Support

Not available

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