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Original Research Article

Placental stiffness assessment using shear wave elastography in normal and preeclamptic pregnancies: a cross-sectional analytical study

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ABSTRACT

Background: Preeclampsia is a multisystem hypertensive disorder associated with abnormal placentation and increased placental stiffness. Shear wave elastography (SWE) is a non-invasive imaging modality that quantitatively evaluates tissue elasticity. This study aimed to compare placental stiffness in normal and preeclamptic pregnancies and determine an optimal diagnostic cut-off value.

Methods: This hospital-based cross-sectional analytical study was conducted in the Department of Radiodiagnosis at Dr. S.N. Medical College, Jodhpur between January 2025 and December 2025. A total of 120 pregnant women between 27-40 weeks of gestation were enrolled: 60 normotensive controls and 60 preeclamptic patients. Placental SWE measurements were obtained using a Philips Affiniti 70 ultrasound system. Nine readings were taken from fetal, central, and maternal placental regions. Receiver operating characteristic (ROC) curve analysis was performed to determine diagnostic performance.

Results: Mean SWE was significantly higher in preeclamptic women compared to controls (4.59±0.41 m/s vs 2.51±0.10 m/s; p=0.068). Median SWE values yielded an AUC of 0.968. A cut-off value of 4.32 kPa demonstrated sensitivity of 86.7% and specificity of 96.7%. Central placental regions showed significantly higher stiffness in preeclamptic pregnancies.

Conclusions: Placental stiffness measured by SWE is significantly increased in preeclampsia. SWE may serve as a reliable, safe, and non-invasive adjunct tool for evaluating placental pathology and identifying pregnancies at risk.

Keywords: ARFI, Placenta, Placental stiffness, Preeclampsia, Shear wave elastography, Ultrasound

INTRODUCTION

Preeclampsia affects approximately 5-8% of pregnancies and remains a leading cause of maternal and perinatal morbidity worldwide.[1-3] It is characterized by new-onset hypertension after 20 weeks of gestation, often accompanied by proteinuria or end-organ dysfunction.[4] The disorder originates from abnormal placentation, particularly defective spiral artery remodelling, leading to placental ischemia, oxidative stress, and endothelial dysfunction.[5]

Histopathological findings in preeclampsia include villous infarction, fibrinoid necrosis, syncytial knot formation, and increased peri-villous fibrin deposition. These structural alterations increase placental stiffness.[6,7]

Shear wave elastography (SWE) is an ultrasound-based technique that quantitatively measures tissue stiffness by

assessing shear wave velocity (SWV). Because pathological tissues are generally stiffer than normal tissues, SWE offers potential as a non-invasive method for placental evaluation.[8]

This study was conducted to evaluate placental stiffness in preeclamptic pregnancies and determine the diagnostic utility of SWE.

METHODS

This hospital-based cross-sectional analytical study was conducted at Dr. S.N. Medical College, Jodhpur in the department of Radio-diagnosis, between January 2025 and December 2025, on patients referred by obstetrics and gynaecology department.

Inclusion criteria

A sample of 120 pregnant women (27-40 weeks' gestation) who provided their consent were included in the study. Out of these 120 patients, 60 patients were normal healthy pregnant women and 60 were preeclamptic pregnant women. Pregnant women with pre-eclampsia (27-40 weeks of gestation) and Healthy pregnant women (who had no risk factors for the diagnosis of preeclampsia) (27-40 weeks of gestation) were included in the study.

Exclusion criteria

Patients with posterior and lateral placental presentation (placenta located 8cm below skin surface) and other fetal anomalies and obstetric pathologies such as diabetes, polyhydramnios, hydrops fetalis, single umbilical artery were excluded from the study.

Placental ultrasound examinations and measurements were performed by a single observer on Philips affinity70 Ultrasound machine, (Philips Medical System, Bothell, WA) using C5-1 (1e5 MHz) convex probe and LOGIQ-E10. A region of interest in the placental parenchyma, free of large blood vessels, was selected and placental echogenicity and homogeneity were evaluated by grey scale before proceeding to elastography. SWE shear wave velocity was measured in meters per second. Placenta was divided into 3 equal parts: Foetal edge (inner 1/3 of placenta), Maternal edge (outer 1/3 of placenta), Central part (central 1/3 of placenta). Three measurements were taken from each part, so total of 9 successful measurements were performed for each patient in the placenta. Mean and median of SWE values were calculated.

Statistical analysis

Descriptive statistics for studied variables were presented as mean, standard deviation (SD), minimum and maximum values. For discrimination of the control and patient groups, cut-off values of shear wave elasticity were determined by receiver–operator curve analysis. The sensitivity and specificity were calculated. Statistical significance levels were considered as 5%. SPSS version 30.0 was used for all statistical computations.

RESULTS

The mean age of normal pregnant women was 26.0 (SD=5.53) years and pre-eclamptic pregnant women was 25.6 (SD=7.07) years. The results obtained showed that there was no significant difference in mean age between the two groups (p=0.51).

Table 1: Demographic characteristics.

Parameters	Normal pregnant women (n=60)	Pre-eclamptic pregnant women (n=60)	P value
Age (years)	26.0±5.53	25.6±7.07	0.51
Gestational age (weeks)	29.7±2.82	31.3±3.53	0.034
Body Mass Index (BMI)	32.2±1.2	34.5±1.4	0.45
Obese, N (%)	37 (61.66)	35 (58.33)	0.70
Primigravid, N (%)	36 (60)	30 (50)	0.27

The mean gestational age in normal pregnant women was 29.7 (SD=2.82) weeks and in pre-eclamptic pregnant women was 31.3 (SD=3.53) weeks. The results obtained showed that there was a significant difference in mean gestational age between the two groups (p=0.034).

The mean systolic and diastolic blood pressures in pre-eclamptic pregnant women were 152.40 (SD=35.35) mm Hg and 95.22 (20.21) mm Hg respectively. Similarly, the mean protein-creatinine ratio in pre-eclamptic pregnant women were 4.09 (SD=4.37).

The mean SWE value in normal pregnant women was 2.51 (SD=0.10) and in pre-eclamptic pregnant women was 4.59 (SD=0.41). The results obtained showed that there was a significant difference in SWE values between the two groups (p=0.068).

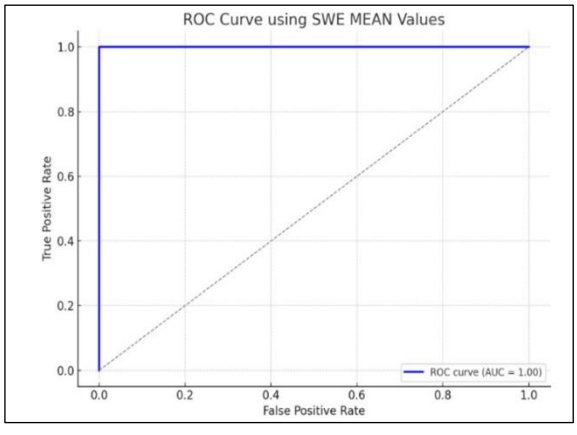

Figure 1: Receptor Operating Curve for SWE.

The ROC curve analysis of placental SWE MEDIAN values yielded an Area under the curve of 0.968. The optimal cut-off value of 4.32 kPa had a sensitivity of 86.7% and specificity of 96.7% for predicting preeclampsia.

DISCUSSION

The study found that the mean age of normal pregnant women was 27.0 (SD=4.73) years and that of pre-eclamptic women was 27.77 (SD=5.23) years, with no statistically significant difference in age between the two groups. Further, the present results show a significant difference in gestational age, with pre-eclamptic women presenting later in pregnancy (33.27±3.53 weeks) compared to normal pregnancies (29.9±2.07 weeks), consistent with the clinical course of preeclampsia, which often leads to late-onset complications. The mean systolic and diastolic blood pressures in pre-eclamptic women were elevated (153.67±22.04 mmHg and 95.33±11.36 mmHg, respectively), affirming the diagnostic clinical criteria of preeclampsia.

Additionally, the mean protein-creatinine ratio was 3.83 (SD=4.96), indicating significant renal involvement. The mean SWE (VTQ) value of the placenta in normal pregnant women was 0.96 (SD=0.17) m/s, while in pre-eclamptic pregnant women it was significantly higher at 1.99 (SD=0.44) m/s (p=0.001). This strongly suggests that placental stiffness is significantly increased in preeclampsia, likely due to impaired placental perfusion, ischemia, and fibrosis associated with the disease pathophysiology.

This finding is consistent with Alan et al, who reported ARFI velocities of 1.09 (SD=0.20) m/s in normal and 1.31 (SD=0.35) m/s in pre-eclamptic pregnancies.[9] Further, Yuzuncu Yil University found values of 0.94 (SD=0.27) m/s in normal and 2.10 (SD=0.11) m/s in pre-eclamptic pregnancies. Similarly, Alan et al reported mean ARFI velocities of 1.09 m/s in normal and 2.20 m/s in pre-eclamptic pregnancies.[10] Compared to these, present findings (0.96 m/s vs 1.99 m/s) are within the expected range and reinforce the utility of SWE in detecting placental abnormalities.

Further, present study observed no significant difference in SWE values between the central and peripheral placental regions in normal pregnancies. However, in pre-eclamptic pregnancies, a statistically significant difference was found (central SWE value: 2.80 m/s; peripheral SWE value: 1.67 m/s). This suggests that preeclampsia affects the central placenta more severely, particularly around the umbilical cord insertion site, consistent with the vascular pathophysiology of the disease. These results align with the studies of Switkowski et al and Meena et al, who found similar regional variations in placental stiffness.[11,12]

Preeclampsia is a multisystem disorder of pregnancy originating from abnormal placentation. Poor trophoblastic invasion and spiral artery remodeling lead to placental ischemia and hypoxia, initiating a cascade of inflammatory, oxidative, and endothelial responses. This contributes to increased placental stiffness, which elastography is uniquely capable of quantifying non-invasively.

Moreover, studies have shown that preeclampsia is associated with syncytial knots, infarcts, decidual vasculopathy, and altered villous architecture, all contributing to the elevated stiffness detected by SWE.[13]

Safety is a crucial concern in obstetric imaging. The use of SWE is supported by several safety evaluations. Sugitani et al investigated the biological impact of SWE on postpartum placentas and found no histological damage.[12] Similarly, Karaman et al concluded that elastographic examination, when conducted within diagnostic ultrasound guidelines, is safe for fetal and maternal tissues, especially due to the low mechanical index and short duration of acoustic pulses.[14]

Our study benefits from a well-matched control group, uniform imaging protocols, and consistent operator measurement. Nonetheless, limitations include sample size, single centre design, and lack of histopathological confirmation in every instance.

CONCLUSION

This study demonstrates that placental stiffness measured by shear wave elastography (SWE) is significantly higher in pre-eclamptic pregnancies compared to normal pregnancies, reflecting underlying placental ischemia and fibrosis. Notably, stiffness was greater in the central placental region, supporting the view that preeclampsia more severely affects areas near the umbilical cord insertion. These findings are consistent with previous studies and highlight the potential of SWE as a safe, non-invasive tool for assessing placental health and aiding in the early detection of preeclampsia.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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