Biomedical and Biopharmaceutical Research

Abbreviation: Biomed. Biopharm. Res.
Volume: 22: Issue: 02 |Year: 2025
Page Number: 837-842

UTILITY OF SHEAR WAVE ELASTOGRAPHY IN EVALUATING RENAL STIFFNESS AND CORRELATION WITH BIOCHEMICAL PARAMETERS IN CHRONIC KIDNEY DISEASE PATIENTS

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Received:22-06-2025

Accepted:01-08-2025

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ABSTRACT

AIMS AND OBJECTIVES: To explore the ability of shear wave elastography (SWE)-derived Young's modulus (YM) as a marker for detecting abnormal renal parenchyma in patients with impaired estimated glomerular filtration rate (eGFR) and biochemical parameters.
To use SWE to detect the severity of renal fibrosis
To compare elastography data between renal disease patients and healthy controls
MATERIALS AND METHODS:
This is a prospective study conducted on 30 CKD patients and 40 control subjects .kidney length and cortical thickness are measured using conventional ultrasound .Renal cortical stiffness was measured by performing shear wave elastography. SWE and conventional ultrasound are correlated with creatinine urea level and eGFR .This study was conducted at ASRAM medical college for a period of 6 month(JUNE 2024 TO NOV 2024).
MACHINE :Mindray RESONA I9
INCLUSION CRITERIA :
CONTROLS:serum creatinine 0.6 to 1.1 mg/dl, serum urea 17-43 mg/dl,eGFR of (>90ml min–1/1.73 m2)
renal cortex to skin surface depth of less than 7 cm, who controls their breathing
CASES:
CKD caused by various etiologies
abnormal eGFR (<90 ml–1min/1.73 m2)
Dearranged biochemical parameters, renal cortical thickness > 1cm
EXCLUSION CRITERIA for CASES AND CONTROLS :
Obese patients ,who are unable to control their breathing
who refused to give consent for the study
renal cortical thickness <1cm
RESULTS :
A total of 70 individuals were included in the study, with 40 participants as controls (GFR > 90ml/min), having a mean KPa of 4.62. The remaining 30 participants were patients with chronic kidney disease (CKD), classified as follows:
- 50% were in CKD Stage 2 with a mean KPa of 6.51.
- 27% were in CKD Stage 3 with a mean KPa of 7.3.
- 17% were in CKD Stage 4 with a mean KPa of 9.2.
- 6% were in CKD Stage 5 with a mean KPa of 11.4.
AIM AND OBJECTIVES:
- To explore the potential of shear wave elastography (SWE)-derived Young's modulus (YM) as a marker for detecting abnormal renal parenchyma in patients with impaired estimated glomerular filtration rate (eGFR) and biochemical parameters.
- To detect the severity of renal fibrosis using SWE.
- To compare elastography data between renal disease patients and healthy controls.

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INTRODUCTION

Chronic Kidney Disease (CKD) is a progressive and irreversible loss of renal function. It is most commonly caused by diabetes mellitus, hypertension, and other renal pathologies. This leads to renal parenchymal scarring and potentially end-stage renal disease.

Conventional imaging like ultrasound evaluates features such as renal size, parenchymal thickness, and echogenicity. However, echogenicity is subjective and lacks quantitative accuracy.

Shear Wave Elastography (SWE) is a modern, non-invasive ultrasound modality that provides a quantitative estimate of tissue stiffness by generating and measuring the velocity of shear waves in tissue. It is already established in liver fibrosis and is now being explored in renal imaging.

NEED FOR THE STUDY

CKD is often detected late due to limitations in conventional diagnostic techniques. SWE offers promise as an early detection tool. Early diagnosis and monitoring of renal fibrosis can reduce morbidity.

MATERIALS AND METHODS

Study Area: ASRAM Medical College, Eluru
Subjects: 70 participants (30 CKD patients and 40 healthy controls)
Design: Prospective study
Equipment: Mindray RESONA I9 Ultrasound Machine

Technique:
- SWE and B-mode ultrasound were performed with patients in the lateral decubitus position.
- Bipolar length and cortical thickness were measured.
- SWE was performed in the longitudinal axis, targeting the renal cortex.
- Five SWE measurements were taken per kidney.
- Average Young's modulus values (in kPa) were recorded.

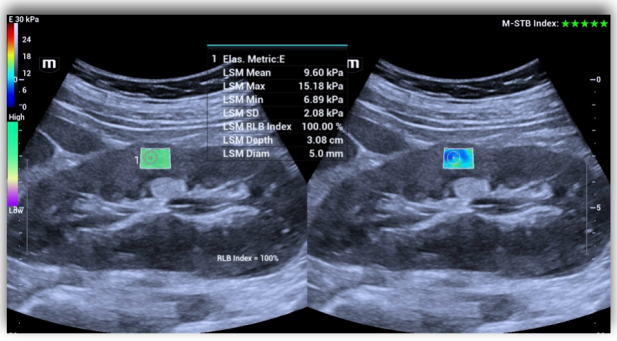
RESULTS AND OBSERVATIONS

Increased Renal Stiffness in CKD:

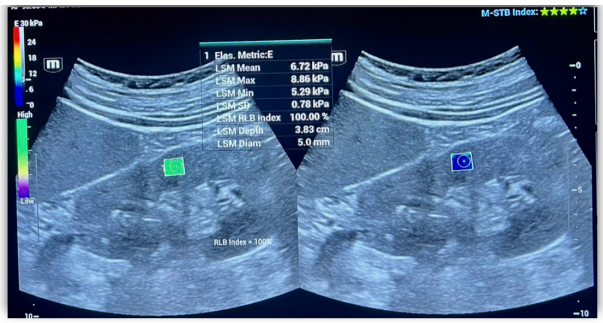
- Shear wave elastography (SWE) shows a significant increase in renal stiffness as CKD progresses.
- Stiffness measurements are higher in advanced stages of CKD compared to early stages.

Correlation with Biochemical Parameters:

- Renal stiffness correlates positively with markers of kidney damage, such as serum creatinine and blood urea levels.
- It inversely correlates with the estimated glomerular filtration rate (eGFR), indicating higher stiffness in patients with reduced kidney function.



SWE of right kidney showing preseved CMD with mild increase in cortical stiffness (mean young modulus 9.60kPa)



- **SWE of right kidney demonstrating mild increase in cortical stiffness (mean youngs modulus 6.72kPa**

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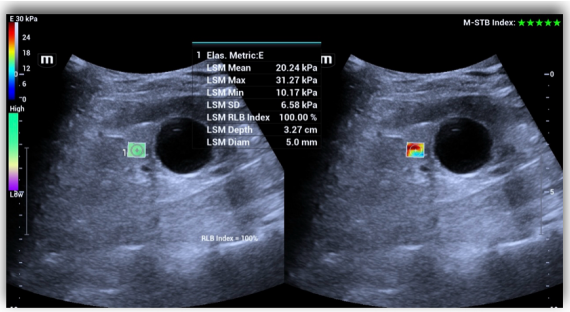
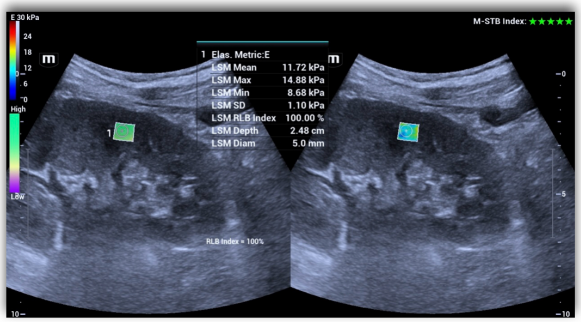


- **SWE of left kidney in a patient with CKD stage 5 showing markedly increase stiffness (mean youngs modulus kPa 20.24)**



- **SWE of right kidney revealing high stiffness with Young's modulus 11.72**

- Out of 70 total subjects, 30 were CKD patients and 40 were controls.
- Among CKD patients:
  - 50% were in Stage 2,
  - 27% in Stage 3,
  - 17% in Stage 4,
  - 6% in Stage 5.
- SWE values increased progressively with CKD severity.

EGFR (ml/ min)	G1 (>90)	G2 (60-90)	G3a (59-45)	G3b (44-30)	G4 (29-15)	G5 (<15)
CREATININE (Mean)	<1.1 mg/dl	1.4 mg/dl	2.5mg/dl	4.2 mg/dl	6.7 mg/dl	12.4 mg/dl
UREA mmol l^{-1}	4.5	5.25	8.68	10.7	13.5	17.6
kPa	4.62	6.51	7.3	9.2	11.4	16.37

-	eGFR	SWE
sensitivity	92.6%	85%
specificity	86%	79.8%

- SWE showed:
  - Positive correlation with serum creatinine and blood urea.
  - Negative correlation with eGFR.
- A Young's modulus cut-off value of ≤ 4.62 kPa was determined to differentiate normal from diseased renal tissue with:
  - Sensitivity: 85%
  - Specificity: 79.8%

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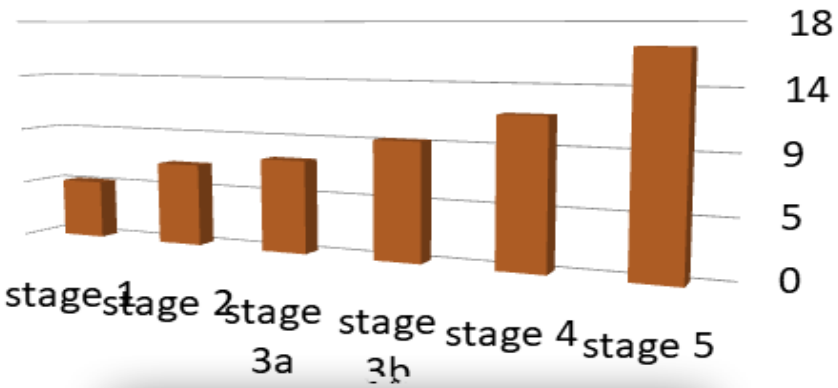
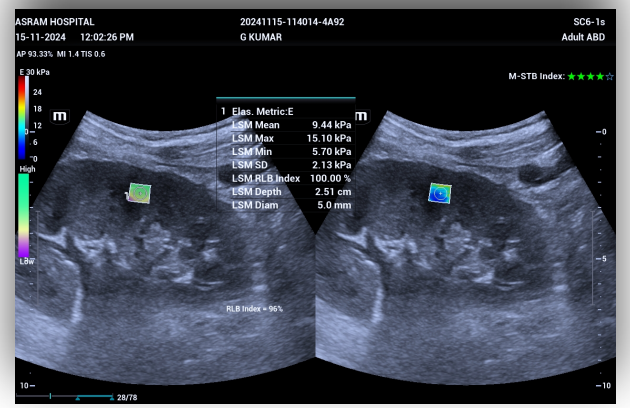
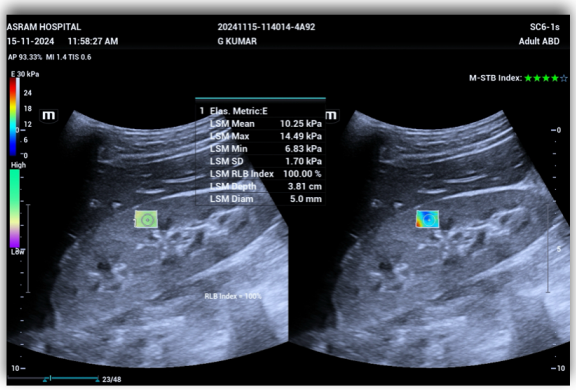




CASE 1



- **42 year old male with CKD stage 4 demonstrating markedly increase renal stiffness with mean Young's modulus of 10.25kPa (left image) and 9.41kPa (right image)**

CASE2

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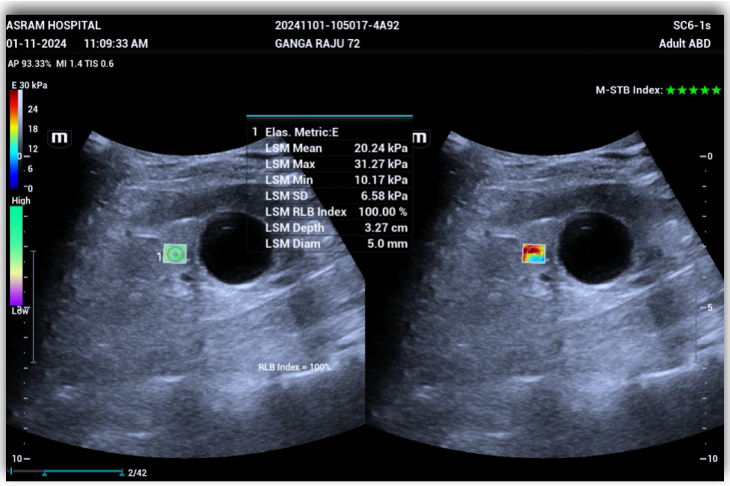
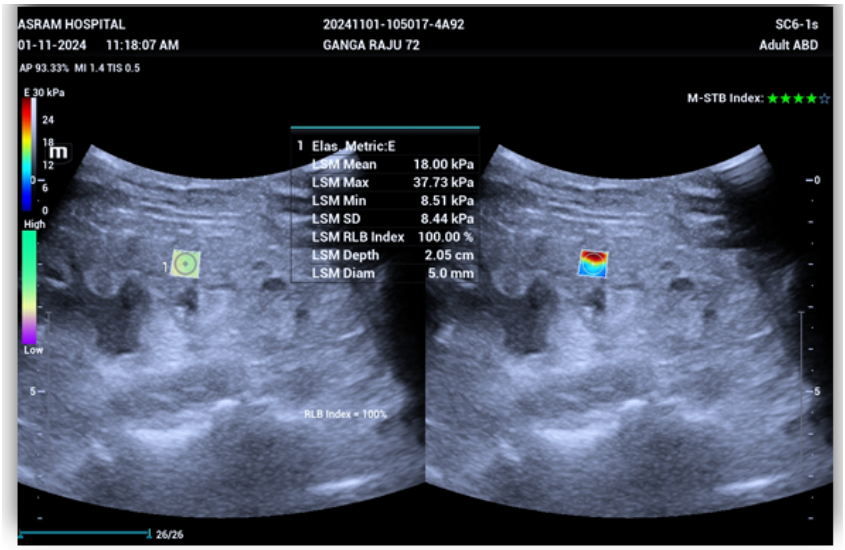


- **72 year old male with CKD stage 5 shows loss of CMD & echogenic parenchyma with Young's modulus 20.24(left image) and 17.31(right kidney)**



DISCUSSION

The study confirmed that SWE is a valuable non-invasive tool in evaluating renal parenchymal stiffness. The ability to correlate SWE values with biochemical markers like serum creatinine and eGFR strengthens its utility in clinical settings.

While renal biopsy remains the gold standard, SWE offers a viable alternative for monitoring and staging CKD, especially in patients where biopsy is contraindicated or unnecessary.

LIMITATIONS

- No direct histopathological correlation (renal biopsy was not performed).
- Operator-dependent variability in SWE technique.
- Small sample size.

CONCLUSION

SWE is a promising, radiation-free, non-invasive modality in the assessment of renal stiffness. It demonstrates good correlation with CKD stages and biochemical parameters. SWE can supplement conventional ultrasound and lab findings, potentially reducing the need for invasive procedures.

CLINICAL APPLICATIONS

- Early detection of CKD in at-risk patients (e.g., hypertensive, diabetic).
- Monitoring CKD progression and response to therapy.
- May reduce dependency on renal biopsy for follow-up evaluations.

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