Shear Wave Elastography in the Evaluation of Renal Parenchymal Stiffness in Patients with Early Diabetic Kidney Disease

Original Article

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ABSTRACT

Background: Diabetic kidney disease (DKD) is one of diabetes serious complications. Early detection and treatment of DKD are important for reducing mortality and giving an opportunity to improve disease prognosis.

Objectives: To assess the role of shear wave elastography in the evaluation of renal parenchymal stiffness in patients with early diabetic kidney disease.

Patients and Methods: This is a prospective comparative study included a total of 90 subjects, divided into 2 groups including control (non-diabetic) and diabetic patient groups. The non-diabetic (control) group included twenty non-diabetic cases with normal renal function tests and calculated GFR, whereas, the patient group comprised seventy patients with diabetes having clinico-laboratory proven diabetic nephropathy. All of the patients were submitted to history taking, clinical examination and laboratory investigations including serum creatinine, estimated GFR and glycosylated Hb test. All subjects underwent kidney assessment using color duplex followed by SWE examination.

Results: There was statistically significant increase in stiffness (kilopascal) of middle zone of both kidneys in patients group [10.4 (6.6-12.1) and 10.05 (5.6-14.7)] compared to control group [3.85 (2.9-4.35) and 3.45 (3-4.25)] with *p-value* < 0.001 with best cut off point >5.1 with sensitivity of (82.14%), specificity of (100.0%) and AUC of (0.932). In addition, the level of velocity (m/s) showed significantly increase in patients group [1.55 (1.2-2.1) and 1.8 (1.1-2.1)] than control group [1.3 (1.2-1.45) and 1.2 (1.05-1.4)] with *p-value* =0.002. The best cut off point for velocity was > 1.7 with sensitivity of (47.86%), specificity of (92.50%) and AUC of (0.704). Also, there was statistically significant positive correlation between RI, stiffness and velocity of shear wave in patients group.

Conclusions: Shear wave elastography is a useful tool in diagnosing early diabetic kidney disease.

Key Words: Diabetic kidney disease (DKD), renal parenchymal stiffness, shear wave elastography.

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INTRODUCTION

One of the most common causes of kidney dysfunction is diabetes mellitus (DM)[1]. Type 2 DM (T2DM) promotes increased permeability to protein and triggers endothelial dysfunction[2]. Diabetic kidney disease (DKD) leads to chronic kidney disease (CKD)[3]. If timely diagnosed and treated, it can be controlled or even be reversed. Depending on the presence of albuminuria, a decline in GFR and the degree of fibrosis, diabetic kidney disease is clinically diagnosed[4]. In early stages, albuminuria, serum creatinine, and estimated glomerular filtration rate (eGFR) are less reliable indicators[5].

Biopsy is the "gold standard" method used to detect early glomerular affection[6], which is invasive, life-threatening and unsuitable when follow-up is required and sampling errors are possible[7]. Magnetic resonance imaging (MRI) and Computed tomography (CT) can evaluate the function and morphology of the kidney. However, they have disadvantages such as long waiting times, radiation exposure, higher costs, and nephropathy induced because of contrast. Ultrasonography is mostly used as an imaging method as a cheap, noninvasive method to evaluate renal disease where renal volume and cortical echogenicity and thickness are used as markers of kidney disease[8]. Those markers appear in the advanced stage although they are well correlated with

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albuminuria and estimated glomerular filtration rate[9]. In the hyperfiltration stage of kidney affection parenchymal thickness, echogenicity and the size of the kidney are still normal so the early stages diagnosis is difficult[9]. Shear wave elastography (SWE) technique is advanced, simple, noninvasive, and has been upgraded to assess quantitatively parenchymal stiffness development[10].

PATIENTS AND METHODS

This is a prospective comparative study included a total of 90 subjects, divided into 2 groups including control (non-diabetic) and diabetic patient groups. The non-diabetic (control) group included twenty non-diabetic cases with normal renal function tests and calculated GFR, whereas, the patient group comprised seventy patients with diabetes having clinico-laboratory proven diabetic nephropathy with no age nor sex predilection. Patients with other general and renal diseases such as hydronephrosis and malignancy and children below 18 years old were excluded from our study. The patients were enrolled from the inpatient department or outpatient clinic and referred to the unit of ultrasound at Ain Shams University's diagnostic radiology department from May 2023 to September 2023 where our study was conducted.

All of subjects gave informed written consent to be concluded in the study. All of the patients were submitted to history taking, clinical examination, laboratory investigations including serum creatinine, estimated GFR and glycosylated Hb test and kidney assessment using color duplex followed by SWE examination.

Sonographic grading of renal parenchymal changes as grade 0 - Normal sized kidney, cortical echogenicity is less than that of spleen, with well-maintained cortico-medullary differentiation. Grade 1 - Normal sized kidney, cortical echogenicity is same as that of spleen, with maintained cortico-medullary differentiation. Grade 2 - Normal sized kidney, cortical echogenicity is more than that of spleen, decreased cortico-medullary differentiation. Grade 3 reduced renal length, cortical echogenicity is more than that of spleen, with poorly maintained cortico-medullary differentiation.

Techniques:

1. Conventional B-mode US and shear wave elastography

All subjects were instructed to fast for 6 hours before the abdominal ultrasound to minimize bowel gases that could hinder the examination and to inform any incidental findings that could be found. Initially, conventional B-mode ultrasound examination was performed then color Doppler and shear wave elastography examination using an up-to-date ultrasonography machine (Phillips EPIQ 7) using a convex arrayed probe (3-5 MHz) for color duplex and SWE examination. Initially, conventional ultrasound images were obtained to assess anteroposterior dimension, parenchymal thickness, and echogenicity in relation to the perinephric fat of both kidneys. Careful attention to renal morphology and perirenal space to exclude any parenchymal diseases was also assumed.

SWE examination is then performed over the B-mode US image, the transducer is kept in a stable position without pressure for a few seconds perpendicularly to better reduction of compression artifact, and the patient was told to hold their breath. Kidney stiffness (KS) is quantitatively measured; the mean value is displayed and exhibited in kilopascals (kPa). Ten measurements of KS using region of interest (ROI=5mm) were placed at the middle zone of both kidneys. The mean value of KS was calculated as indicative of fibrosis and expressed in kilopascals (kPa). SWE mean kidney stiffness values are then correlated with color duplex and laboratory findings.

2. Color duplex sonography:

To exclude renal artery stenosis, first we examined the descending abdominal aorta and main renal arteries. Peak Systolic Velocity (PSV), End Diastolic Velocity (EDV), S\D ratio, and Resistive Index (RI) measurements in segmental renal arteries and main renal artery were measured.

Statistical Analysis

Data were collected, revised, coded, and tabulated to the Statistical Package for Social Science (IBM SPSS 27). Quantitative data found as parametric presented as mean, standard deviations, and ranges and the non-parametric presented as median, inter-quartile range (IQR) and compared by using the chi-square test. The differences in continuous variables were analyzed by using Mann-Whitney U test. Qualitative variables were presented as percentages and numbers. The *p-value* was considered significant as the following: *P-value* > 0.05: Non-significant (NS), *P-value* < 0.05: Significant (S), *P-value* < 0.01: Highly significant (HS). The correlations between grayscale, and SWE parameters were evaluated with the Pearson's and Spearman's bivariate correlation (r) tests. Receiver operating characteristic (ROC) curves were carried out, and the areas under the curve (AUCs) were estimated.

ETHICAL CONSIDERATION

The Ethical committee approved our study protocol. Research Ethics Committee of The Faculty of Medicine, Ain Shams University granted approval of this study on 28/03/2023; Approval reference Number: FWA 000017585 (No: FMASU M S 192/2023).

RESULTS

The subjects were categorized into 2 groups, including 70 diabetic patients and 20 control. The mean (±SD) value of the BMI for the diabetic group was 28.0 ± 4.0, while for the control group was 29.0 ± 3.0 with no statistically significant difference between both groups ($p = 0.920$).

The 90 recruited individuals included 48 females (53.3%) and 42 males (46.7%) with their ages ranges from 27 to 65 years with mean (±SD) of 50.61 (±8.38) years, where no statistical significant difference between control group and patients group regarding gender and age distribution ($p = 0.735$, and 0.955; respectively).

The median (IQR) duration of diabetes of the diabetic group was 5 years with a total duration ranging between 1 – 27 years. (Table 1).

Table 1: Comparison between control and patient groups regarding demographic data.

General		Control group No.=20	Patients group No.=70	Test-value	*P-value*	Sig.
Age(years)	Mean±SD	50.55 ± 8.29	50.67 ± 8.46	-0.057•	0.955	NS
	Range	30 - 65	27 - 62			
Gender	Female	10 (50%)	38 (54.3%)	0.115*	0.735	NS
	Male	10 (50%)	32 (45.7%)			
Body Mass Index	Mean±SD	29.0 ± 3.0	28.0 ± 4.0	0.101•	0.920	NS
	Range	21.0 – 32.0	19.0 – 38.0			

P-value > 0.05: Non significant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant
*: Chi-square test; •: Independent t-test

There was no statistically significant difference found between control group and patients' group regarding size (volume), or parenchymal thickness (cm) of right kidney with *p-value* = 0.113 and 0.564; respectively while there was a statistically significant increase in the grade of renal echogenicity in patients' group [13 (18.6%)] compared to the control group [0 (0%)] with *p-value* = 0.037. There was no statistically significant difference found between control group and patients' group regarding size, or parenchymal thickness of the left kidney with *p-value* = 0.177 and 0.753; respectively while there was a statistically significant increase in the grade of renal echogenicity in patients' group [13 (18.6%)] compared to control group [0 (0%)] with *p-value* = 0.037 (Table 2).

Table 2: Comparison between control group and patients group regarding B-mode parameters of right and left kidneys.

B-mode		Control group No.=20		Patients group No.=20		Test-value	*P-value*	Sig.	Test-value	*P-value*	Sig.
		Right	Left	Right	Left	Right			Left		
Size (volume)	Mean±SD	142.35±32.71	148.15±34.37	125.67± 43.1	132.95±46.36	1.602•	0.113	NS	1.361•	0.177	NS
	Range	75 – 190	96 – 216	35 – 227	51.8 – 217						
Parenchymal thickness(cm)	Mean±SD	1.38 ± 0.25	1.43 ± 0.26	1.42 ± 0.31	1.45 ± 0.31	-0.579•	0.564	NS	-0.316•	0.753	NS
	Range	0.8 – 1.9	1 – 2	0.7 – 2.0	0.9 – 2.2						
Echogenicity	Not echogenic	20 (100%)	20 (100%)	57 (81.4%)	57 (81.4%)	4.341*	0.037	S	4.341*	0.037	S
	Echogenic	0 (0%)	0 (0%)	13 (18.6%)	13 (18.6%)						

P-value > 0.05: Non significant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant *: Chi-square test; •: Independent t-test; ‡: Mann-Whitney test.

Regarding the main renal artery, there was a statistically significant decrease in PSV (cm/s) of both kidneys of patients' group [43.85 (35–48.2) and 35.25 (33.1–46); respectively] than control group [47.75 (43.15–54.75) and 49.5 (44.2–52.7); respectively] with *p-value* = 0.018 and 0.007; respectively. Also, the level of RI showed a significant increase in both kidneys of patients' group [0.66 (0.59–0.72) and 0.71 (0.61–0.78); respectively] than control group [0.58 (0.55–0.63) and 0.58 (0.53–0.62); respectively] with *p-value* = 0.002 and <0.001; respectively. Additionally, RI showed a significant increase in both kidneys of patients' group [0.61 (0.55–0.64) and 0.63 (0.56–0.65); respectively] than control group [0.52 (0.49–0.58) and 0.53 (0.47–0.56); respectively] with *p-value* = 0.002 and <0.001; respectively. While the S/D ratio showed a significant increase in both kidneys of patients' group [2.55 (2.2–2.9) and 2.55 (2.2–2.9); respectively] than control group [2.15 (1.85–2.4) and 2.1 (1.9–2.3); respectively] with *p-value* = 0.002 and <0.001; respectively (Table 3).

Table 3: Comparison between control group and patients group regarding right and left kidneys renal Doppler data.

Doppler		Control group No.=20		Patients group No.=70		Test value	*P-value*	Sig.	Test-value	*P-value*	Sig.
Main renal artery		Right	Left	Right	Left	Right			Left		
PSV(cm/s)	Median(IQR)	47.75 (43.15–54.75)	49.5 (44.2–52.7)	43.85 (35–48.2)	35.25 (33.1–46)	-2.360	0.018	S	-2.675	0.007	HS
	Range	33.1 – 64.7	26.2 – 67.4	21.9 – 84.3	23.5 – 70.6						
RI	Median(IQR)	0.58 (0.55–0.63)	0.58 (0.53–0.62)	0.66 (0.59–0.72)	0.71 (0.61–0.78)	-3.102	0.002	HS	-4.384	0.000	HS
	Range	0.51 – 0.71	0.47 – 0.7	0.47 – 0.83	0.45 – 0.87						
S\D ratio	Median(IQR)	2.35 (2.15–2.55)	2.3 (2.1–2.65)	2.95 (2.4–3.6)	3.45 (2.6–4.4)	-3.307	0.001	HS	-4.648	0.000	HS
	Range	2.0 – 3.4	1.8 – 3.4	0 – 5.8	2.1 – 6.6						
Segmental artery											
PSV	Median(IQR)	33.55 (31.4–34.4)	31.6 (25.8–38.3)	25.4 (19.4–30.1)	26.85 (21.9–32.3)	-4.064	0.000	HS	-2.301	0.021	S
	Range	28.3 – 40.8	18.5 – 54.7	14.5 – 55.9	15.1 – 66.8						
RI	Median(IQR)	0.52 (0.49–0.58)	0.53 (0.47–0.56)	0.61 (0.55–0.64)	0.63 (0.56–0.65)	-3.029	0.002	HS	-4.460	0.000	HS
	Range	0.4 – 0.64	0.45 – 0.61	0.45 – 0.75	0.45 – 0.81						
S\D ratio	Median(IQR)	2.15 (1.85–2.4)	2.1 (1.9–2.3)	2.55 (2.2–2.9)	2.55 (2.2–2.9)	-3.134	0.002	HS	-3.962	0.000	HS
	Range	1.6 – 2.8	1.8 – 2.5	1.8 – 4.1	1.8 – 5.3						

P-value > 0.05: Non significant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant *: Chi-square test; •: Independent t-test; ‡: Mann-Whitney test

As regarding to SWE examination of both studied groups, the results of this study showed that there was a statistically significant increase in stiffness (kilopascal) of both kidneys of patients' group [10.4 (6.6-12.1) and 10.05 (5.6-14.7); respectively] than control group [3.85 (2.9-4.35) and 3.45 (3-4.25); respectively] with *p-value* < 0.001 and <0.001; respectively.

Also, the level of velocity (m/s) showed a significant increase in both kidneys of patients' group [1.55 (1.2-2.1) and 1.8 (1.1-2.1); respectively] than control group [1.3 (1.2-1.45) and 1.2 (1.05-1.4); respectively] with *p-value* = 0.020 and 0.002; respectively (Table 4).

Table 4: Comparison between control group and patients group regarding right and left kidneys' SWE values.

SWE values		Control group No.=20		Patients group No.=70		Test value	*P-value*	Sig.	Test-value	*P-value*	Sig.
		Right	Left	Right	Left	Right			Left		
PSV(cm/s)	Median (IQR)	3.85 (2.9-4.35)	3.45 (3-4.25)	10.4 (6.6-12.1)	10.05 (5.6-14.7)	-5.946‡	0.000	HS	-5.830‡	0.000	HS
	Range	2 – 5	2.3 – 5.1	2 – 23.5	3 – 19.6						
RI	Median (IQR)	1.3 (1.2-1.45)	1.2 (1.05-1.4)	1.55 (1.2-2.1)	1.8 (1.1-2.1)	-2.322‡	0.020	S	-3.085‡	0.002	HS
	Range	1 – 1.8	0.8 – 1.9	0.8 – 6	1 – 5.5						

P-value > 0.05: Non significant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant
*: Chi-square test; •: Independent t-test; ‡: Mann-Whitney test

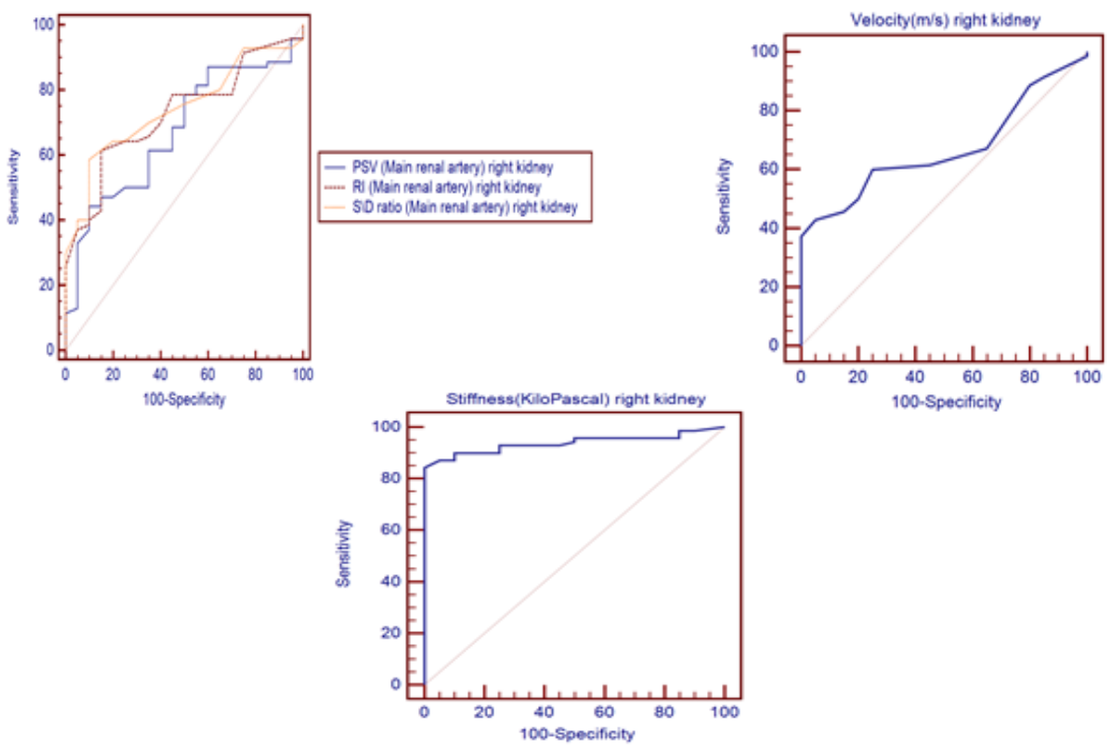

Fig. 1: Receiver operating characteristic curve of right kidney measurements as a predictor to differentiate patients from controls.

The ROC curve for RI showed that a cut-off point >0.65 can differentiate between the two groups at with sensitivity of 55.71% and, specificity of 90.00%.While for S/D ratio with an AUC of 0.795, the best cut-off point was found >2.8 with sensitivity of 60.00%, specificity of 90.00%. Also, regarding the shear wave, a cut-off point for stiffness was >5.1 with sensitivity of 82.14%, specificity of 100.0%. While the best cut-off point for velocity was > 1.7 with sensitivity of 47.86%, specificity of 92.50% and AUC of 0.704 (Table 5).

Table 5: Receiver operating characteristic curve of both kidneys measurements as a predictor to differentiate patients from controls.

	AUC	Cut of Point	Sensitivity	Specificity	PPV	NPV
Main renal artery						
PSV	0.690	<=40.4	50.71	85.00	92.2	33.0
RI	0.778	>0.65	55.71	90.00	95.1	36.7
S/D ratio	0.795	>2.8	60.00	90.00	95.5	39.1
Shear wave						
Stiffness	0.932	>5.1	82.14	100.00	100.0	61.5
Velocity	0.704	>1.7	47.86	92.50	95.7	33.6

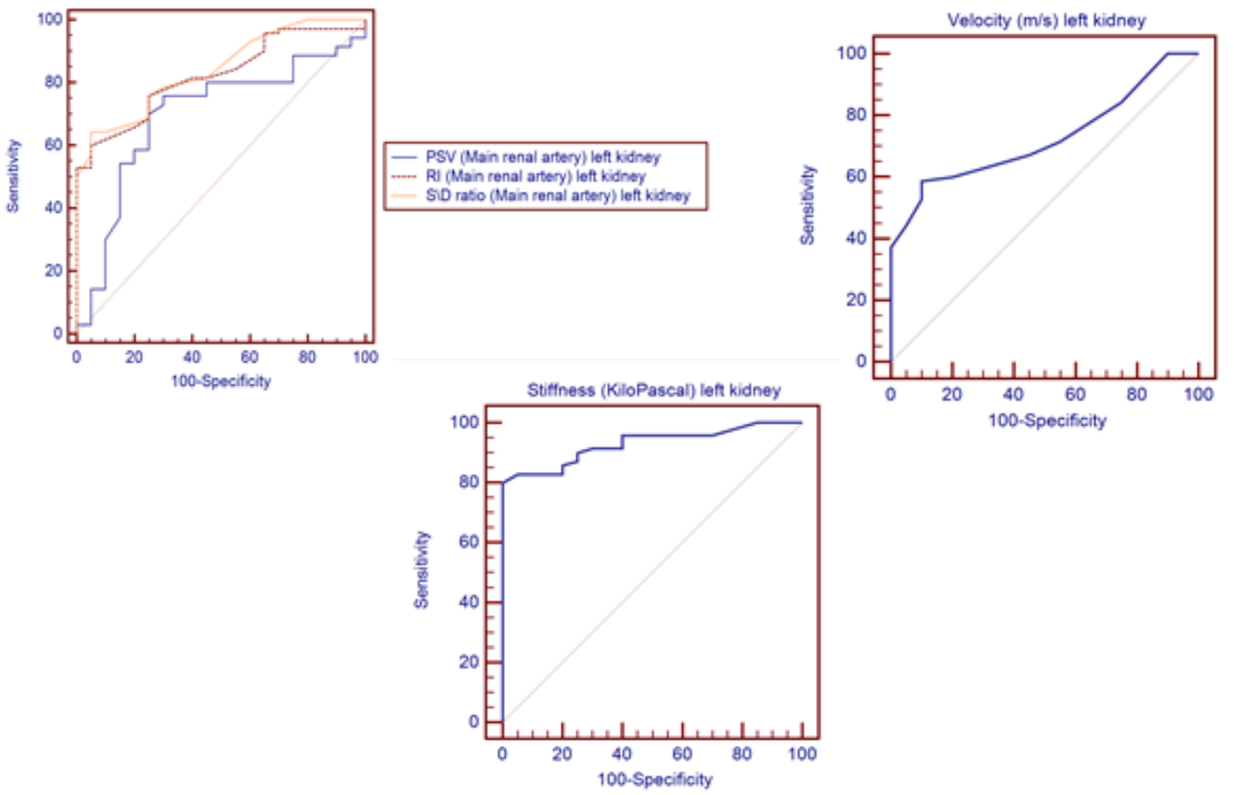

Fig. 2: Receiver operating characteristic curve of left kidney measurements as a predictor to differentiate patients from controls.

There was a statistically significant negative correlation between parenchymal thickness and velocity in control group (r =-0.575, *P value*=0.008) and patients group (r=0.326, *P value* =0.006). Also, there was a statistically significant negative correlation found between PSV (main renal artery) and velocity among control group (r =-0.669, *P value*= 0.001) (Table 6).

Table 6: Correlation of shear wave in right kidney with other studied parameters in control and patients group.

		Control group	Patient group
Parenchymal thickness(cm)			
Stiffness (KiloPascal	r	-0.153	0.231
	P-value	0.521	0.054
Velocity (m/s)	r	-0.575**	0.326**
	P-value	0.008	0.006
PSV (main renal artery)			
Stiffness (KiloPascal	r	-0.233	0.045
	P-value	0.322	0.709
Velocity (m/s)	r	-0.669**	0.082
	P-value	0.001	0.500

Spearman correlation coefficients

Regarding renal Doppler, there was a statistically significant positive correlation found between RI of the main renal artery (r=0.453, *P value*=0.000) with a velocity of shear wave in patients group (Table 7).

Table 7: Correlation of shear wave in right kidney with other studied parameters in control and patients group

		Control group	Patient group
RI (main renal artery)			
Stiffness (KiloPascal	r	-0.122	0.155
	P-value	0.608	0.200
Velocity (m/s)	r	0.442	0.453**
	P-value	0.051	0.000

There was a statistically significant negative correlation found between parenchymal thickness and velocity of shear wave in patients group (r=-0.138, *P value*=0.256). Also, there was a statistically significant negative correlation found between PSV (main renal artery) and stiffness and velocity among control group (r =-0.0.013, *P value*= 0.957),(r=-0.215,*P value*=0.363) respectively (Table 8).

Table 8: Correlation of shear wave in left kidney with other studied parameters in control and patients groups.

		Control group	Patient group
Parenchymal thickness(cm)			
Stiffness (KiloPascal	r	0.112	0.008
	P-value	0.639	0.945
Velocity (m/s)	r	0.189	-0.138
	P-value	0.425	0.256
PSV (main renal artery)			
Stiffness (KiloPascal	r	-0.013	0.224
	P-value	0.957	0.062
Velocity (m/s)	r	-0.215	0.197
	P-value	0.363	0.102

There was a statistically significant positive correlation between RI main renal artery and stiffness (r=0.249, *P value*=0.038) and velocity of shear wave (r=0.549, *P value*=0.000)in patients group. (Table 9).

Table 9: Correlation of shear wave in left kidney with other studied parameters in control and patients groups.

		Control group	Patient group
	RI (main renal artery)		
Stiffness (KiloPascal	r	0.060	0.249*
	P-value	0.800	0.038
Velocity (m/s)	r	-0.306	0.549**
	P-value	0.190	0.000

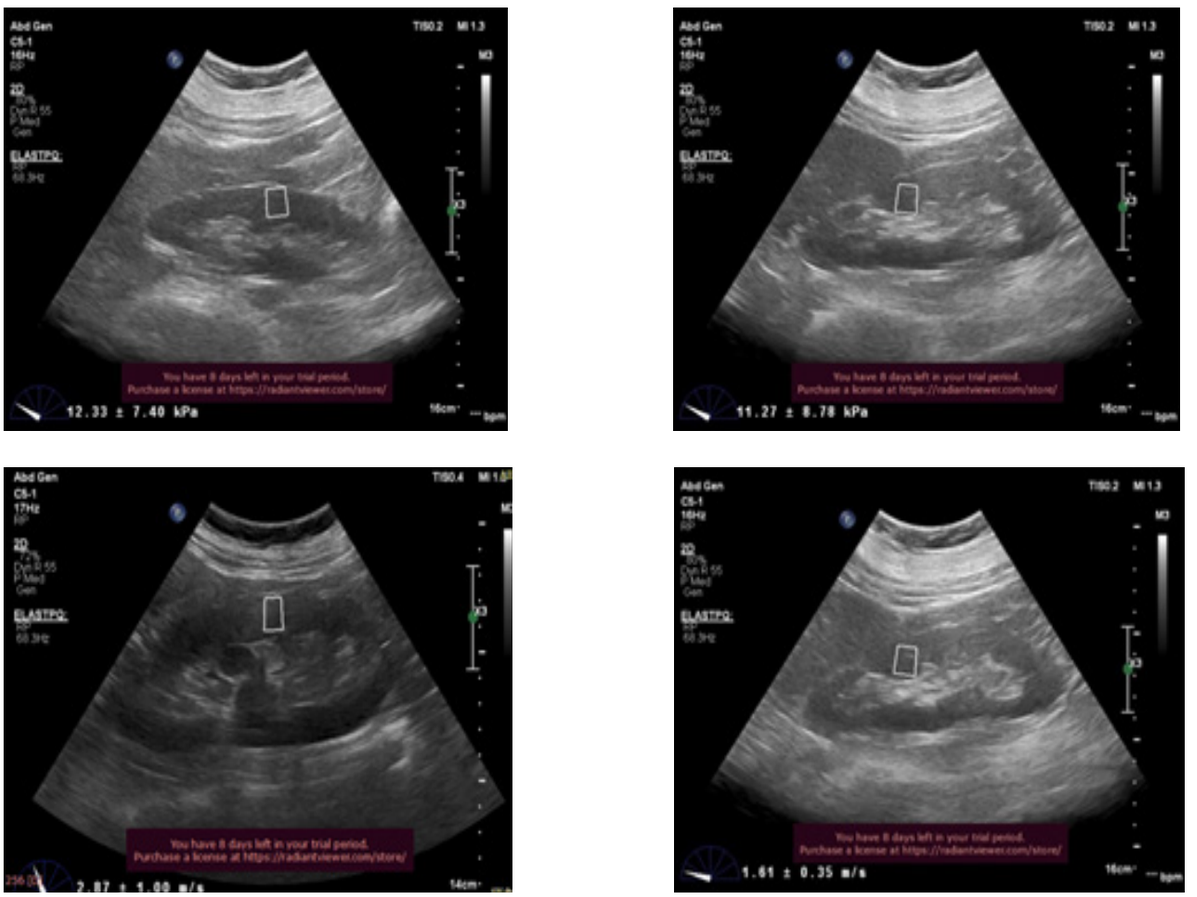

Fig. 3: Female patient 50 years old with a history of DM for 2 years, middle zone stiffness value for the right kidney = 12.3 KPa, velocity for the right kidney= 2.8 m/s, middle zone stiffness value for the left kidney = 11.2 KPa, velocity for the left kidney =1.6m/s.

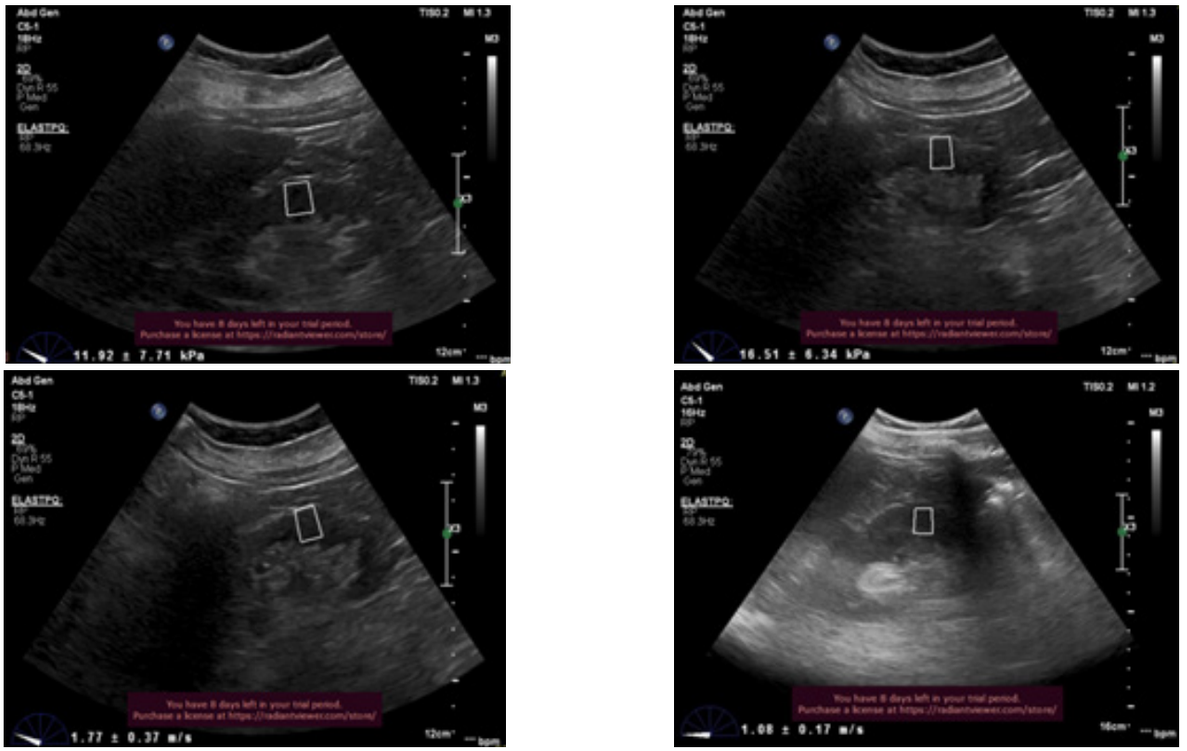

Fig. 4: Female patient, 48 years old with history of diabetes mellitus for 5 years, mean middle zone stiffness value for the right kidney = 11.9 KPa, velocity = 1.48 m/s and for the left kidney stiffness = 16.5 KPa with velocity =1.7m/s.

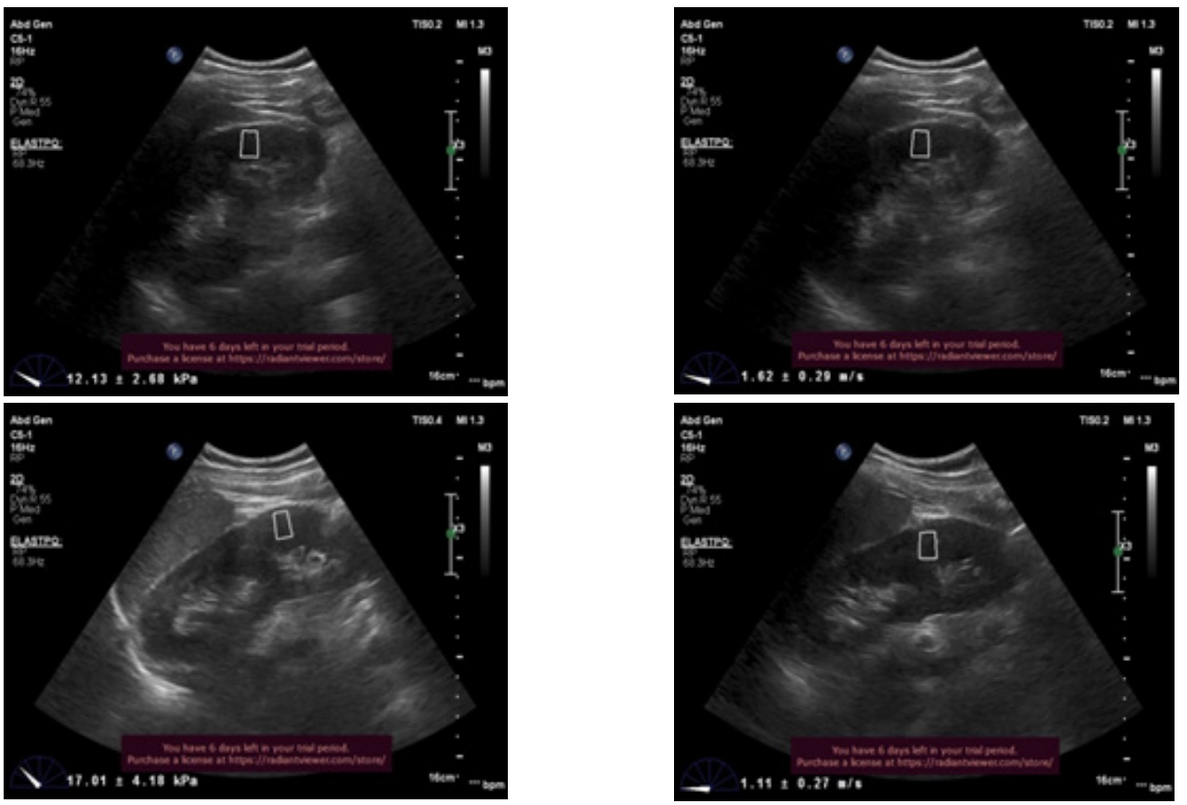

Fig. 5: Male patient 31 years old with history of DM for 4 years, mean middle zone stiffness value for the right kidney = 12.3 KPa, velocity = 1.6m/s and for the left kidney stiffness = 17 KPa with velocity =1.1m/s.

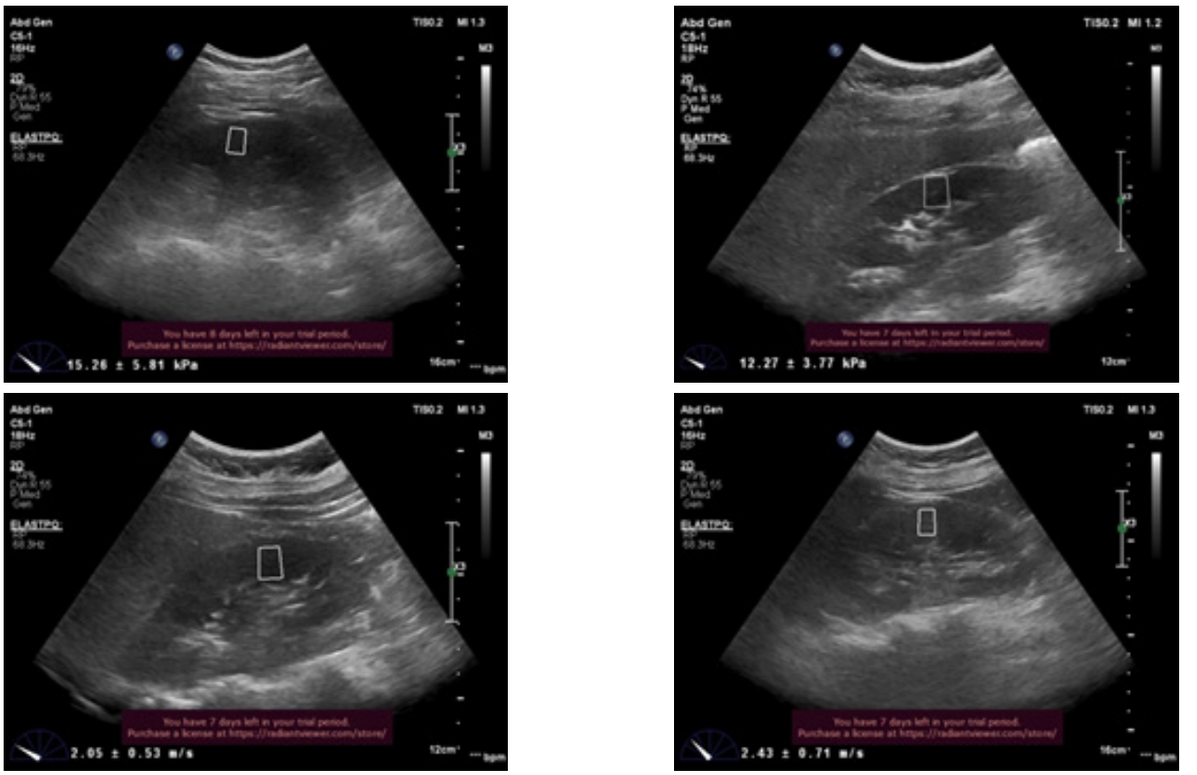

Fig. 6: Female patient 47 years old with history of DM for 1 year, mean middle zone stiffness value for the right kidney = 12.7 KPa, velocity = 2m/s and for the left kidney stiffness = 15.2 KPa with velocity =2.4m/s.

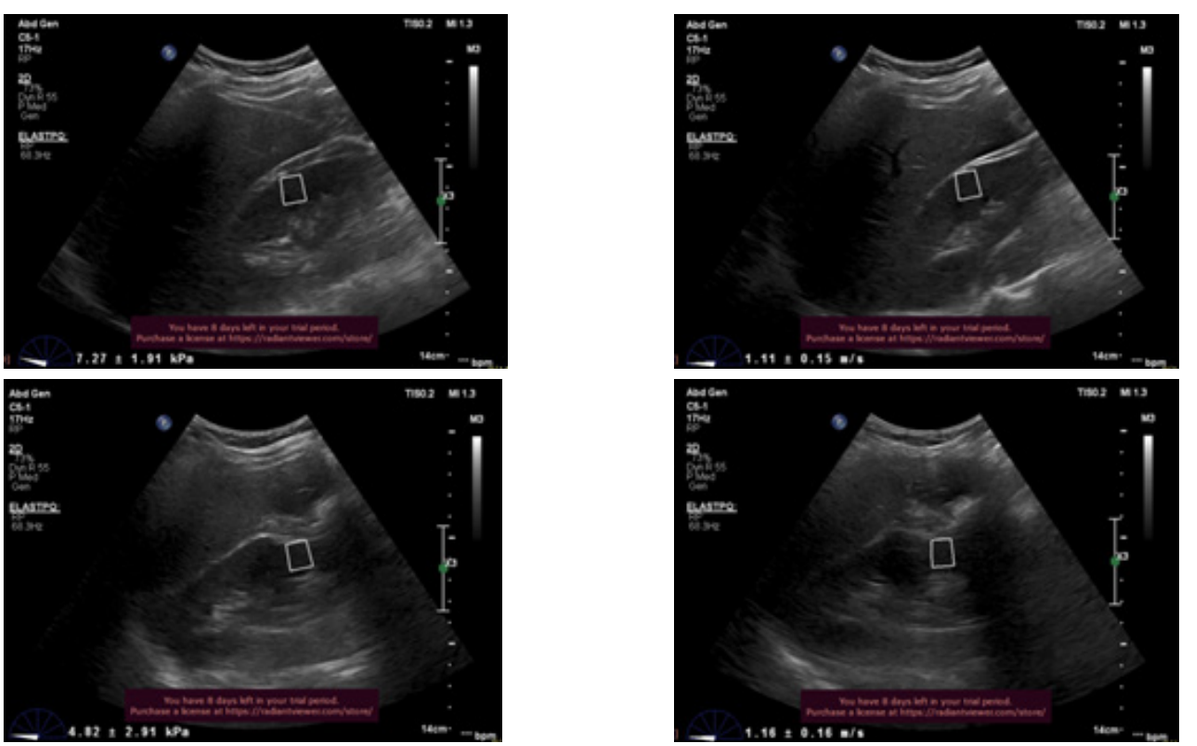

Fig. 7: Male patient 48 years old with no history of diabetes mellitus. Middle zone stiffness value for the right kidney=7 KPa, right kidney velocity = 1.11 m/s, left kidney stiffness = 4.8 KPa with, left kidney velocity =1.16m/s.

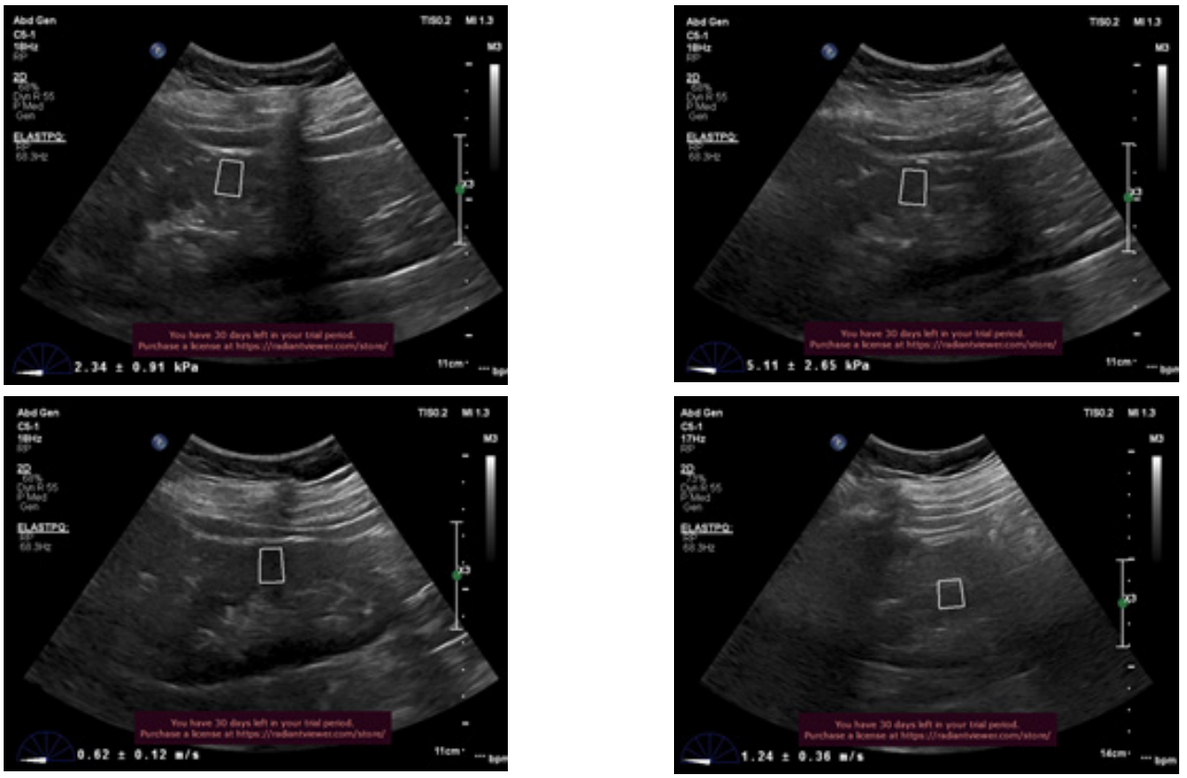

Fig. 8: Female patient 42 years old with no history of diabetes mellitus. Middle zone stiffness value for the right kidney= 2.3 KPa, right kidney velocity = 0.92 m/s, left kidney stiffness = 5.1 KPa with, left kidney velocity =1.2m/s.

DISCUSSION

Early observation of diabetic nephropathy seeks to hinder the development of end-stage renal disease, as well, as provide the optimal control of blood glucose level to prevent other diabetic complications and further progression of renal affection[11]. Renal biopsy is used to be the gold standard for the diagnosis. However, major complications could happen so another non-invasive method should be used[12]. SWE technology, in essence, assesses the wave velocity (in m/s) traveling through studied tissue and translates obtained data into measurement in kPa which represents stiffness[13]. Thus, our principle study investigates the role of shear wave renal elastography in early diabetic kidney disease. In the current study, we enrolled a total of 70 diabetics and 20 healthy controls, we assessed the middle zone of the right and left kidney separately using ultrasound and color Doppler to interpret the findings.

In the current study, the comparison between patient group and control group regarding the main renal arteries indices (PSV, RI, and S/D ratio) by color Doppler showed a statistically significant decrease in PSV (cm/s) in both kidneys of patients' group than control group with *p-value* = 0.018 and 0.007; respectively and significant increase in the level of RI and S/D ratio in both kidneys of patients' than control group with *p-value* = 0.002 and <0.001; respectively. These results are corresponding with the results of the study performed by ***Sistani et al***., which showed that the mean RI in the control group was lower than the mean RI in different stages of diabetic nephropathy. Also, that study defined RI as more than or equal to 0.7 capable of representing kidney function in diabetic patients with microalbuminuria or macroalbuminuria[14].

Our study showed that renal Doppler resistivity indices of both kidneys could foretell diabetic kidney disease with *p-value* <0.001, using a cut-off of 0.65 with sensitivity of 70.00 % and specificity of 77.50%.These findings goes in agreement with retrospective study of 332 diabetic nephropathy patients and 137 non-diabetic nephropathic patients. In the diabetic patients' group; RI was higher in comparison with those in the non-diabetic group (0.70 vs. 0.63, *p*< 0.001). RI cut-off value for predicting diabetic kidney disease was 0.66 of sensitivity (69.2%) and specificity (80.9%)[15].

Similarly, ***Leong et al.*** obtained 4.31 kPa as a cut-off value which a non-diseased kidney suggested if a value less than this is obtained with sensitivity and specificity of 80.3% and 79.5%, respectively. Tantawy & Anwar stated that the cut-off value of SWE modality was 4.45 kPa for prediction fibrosis of the kidney with a sensitivity of 93.30% and specificity of 83.3% (p<0.0001)[16,17]. Other previous studies have scanned the role of SWE in evaluating renal stiffness and resistivity index of renal vessels between diabetic patients versus control group, they obtained that RI was compatible among study groups, while stiffness was higher in DM group, they stated that 8.5kPa a cut-off point for the diagnosis of patients with diabetic kidney disease in comparison with controls of sensitivity 65.2%, specificity 60.4% and AUC 0.708 indicating that microvascular changes occurring in diabetic kidney disease can be detected by SWE compared to color renal Doppler even at the preclinical stage[18].

The marked difference in stiffness values between diabetic patients and control (10.1±1.75Kpa versus 8.2±1.40Kpa with *p-value* <0.001) reported by ***Yuksekkaya et al.***[19]. They also reported 9.23Kpa as cut-off point for diagnosing diabetic nephropathy, and cut-off point of 10.1Kpa for early versus late diabetic nephropathy[19]. These values and cut-off points are higher than values reported in the current study and this may account for variations in machine settings, duration of diabetes, race, and ethnicity of the studies population.

Although the assessment of the renal stiffness changes by SWE has been recently used in diabetic nephropathy, there are no specific standard data on the cut-off value which causes conflicting outcomes[18]. The disadvantages of SWE are that it is not usually available in clinics and the lack of standard cut-off values in the patient population[20]. The measurement of tissue stiffness by ultrasound is troublesome in the kidney because of its deep abdominal positioning. Only sonography-guided procedures appear to be appropriate due to compartmentalization and considerable tissue heterogeneity. The dangers of pressure induced by applying transducer on the anterior abdominal wall and tissue anisotropy, enhance measurement variability. As a result, additional experience in patient cohorts and preclinical assessment with pathological association is required to better assess histological and physical reasons for variation in elasticity[21].

The limitations of our study comprised the small number of the included patients and motion artifacts and limited wave penetration reducing the reliability and validity of SWE in obese patients. Thus, further larger studies including more patients' series, with histopathology references are required.

CONCLUSION

Shear wave elastography is a highly accurate, sensitive, and specific diagnostic tool for evaluation of early diabetic kidney disease.

CONFLICT OF INTEREST

All authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

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التصوير الإلستوجرافي لموجة القص في تقييم تصلب الكلى المتني في المرضى الذين يعانون من مرض الكلى السكري المبكر

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الخلفية: يعد مرض الكلى السكري أحد أخطر المضاعفات التي تصيب مرضى السكري. ويصبح تشخيص المريض سيئًا بمجرد تطور مرض الكلى السكري. ويعد الكشف المبكر عن مرض الكلى السكري وعلاجه أمرًا مهمًا للحد من الوفيات وإتاحة الفرصة لتحسين تشخيص المرض. وقد تم تحسين التصوير بالموجات القصية لتقييم تطور التليف النسيجي كتقنية تصوير بالموجات فوق الصوتية بسيطة ومتقدمة وغير جراحية.

الهدف من البحث: هدف الدراسة هو تحديد دور مرونة الموجات القصية في التقييم الكمي للمراحل المبكرة من تصلب الأنسجة لمرض الكلى السكري المرتبط بالنتائج المخبرية ودوبلر الكلى.

المرضى والطرق: هذه دراسة مقارنة مستقبلية شملت ما مجموعه ٩٠ مريضًا، مقسمين إلى مجموعتين بما في ذلك مجموعات التحكم (غير المصابين بالسكري) ومجموعات مرضى السكري. تضمنت المجموعة غير المصابة بالسكري (الضابطة) عشرين حالة غير مصابة بالسكري مع اختبارات وظائف الكلى الطبيعية ومعدل الترشيح الكبيبي المحسوب، في حين أن مجموعة المرضى تتألف من سبعين مريضًا مصابًا بالسكري يعانون من اعتلال الكلية السكري الذي أثبتته الفحوصات السريرية والمخبرية دون وجود ميل للعمر أو الجنس. تم استبعاد المرضى الذين يعانون من أمراض عامة وكلوية أخرى مثل استسقاء الكلية والأورام الخبيثة والأطفال دون سن ١٨ عامًا من دراستنا. تم تسجيل المرضى من قسم المرضى الداخليين أو العيادات الخارجية وإحالتهم إلى وحدة الموجات فوق الصوتية في قسم الأشعة التشخيصية بجامعة عين شمس من مايو ٢٠٢٣ إلى سبتمبر ٢٠٢٣ حيث أجريت دراستنا.

النتائج: كان هناك زيادة كبيرة إحصائيًا في تصلب (كيلوباسكال) المنطقة الوسطى لكلا الكليتين في مجموعة المرضى [١٠,٤ (٦,٦-١٢,١) و ١٠,٠٥ (٥,٦-١٤,٧)] مقارنة بمجموعة التحكم [٣,٨٥ (٢,٩-٤,٣٥) و ٣,٤٥ (٣-٤,٢٥)] بقيمة $p < ٠,٠٠١$ مع أفضل نقطة قطع > ٥,١ مع حساسية (٨٢,١٤٪) وخصوصية (١٠٠,٠٪) و AUC (٠,٩٣٢). بالإضافة إلى ذلك، أظهر مستوى السرعة (م / ث) زيادة كبيرة في مجموعة المرضى [١,٥٥ (١,٢-٢,١) و ١,٨ (١,١-٢,١)] من مجموعة التحكم [١,٣ (١,٢-١,٤٥) و ١,٢ (١,٠٥-١,٤)] بقيمة $p = ٠,٠٠٢$. كانت أفضل نقطة قطع للسرعة > ١,٧ مع حساسية (٤٧,٨٦٪) وخصوصية (٩٢,٥٠٪) وAUC (٠,٧٠٤). كما كان هناك ارتباط إيجابي ذو دلالة إحصائية بين RI والصلابة وسرعة موجة القص في مجموعة المرضى.

الاستنتاجات: تعد تقنية تصوير موجات القص المرنة أداة تشخيصية عالية الدقة والحساسية والمحددة لتقييم مرض الكلى السكري المبكر.