Renal cortical thickness as an indicator of renal insufficiency in chronic kidney disease

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Background
Chronic kidney disease (CKD) is one of the common causes of renal failure. Renal sonography is an essential diagnostic tool in nephrology. Renal sonographic dimensional parameters could be of great utility, providing indirect but valuable information about the morphostructural changes occurring in the kidney in the course of CKD.

Aim
To determine whether there is a relationship between renal cortical thickness and renal length measured on ultrasound and the degree of renal insufficiency in patients with CKD.

Patients and methods
From December 2016 to October 2017, 50 patients with clinically stable chronic renal insufficiency participated in this study. Renal sonographic parameters including length of the kidney, cortical thickness, and renal echogenicity were measured. Serum creatinine was used for estimated glomerular filtration rate using Cockcroft and Gault equation for all patients.

Results
The most common cause of CKD in our patients was systemic lupus (22%) followed by hypertension (16%). The mean renal length was 97.6 ± 12.2 mm, the mean cortical thickness was 9.38 ± 1.79 mm, the mean serum creatinine level was 2.46 ± 1.74 mg/dl, and the mean value of estimated glomerular filtration rate using Cockcroft and Gault equation was 60.95 ± 53.78 ml/min. There was a high statistically significant relationship between cortical thickness and creatinine clearance ($r = 0.67$, $P < 0.001$), and also statistically significant correlation of renal length with creatinine clearance ($r = 0.42$, $P = 0.002$) was reported, but the strongest relationship was for mean cortical thickness.

Conclusion
Renal cortical thickness measured at ultrasound appears to be more closely related to the degree of renal impairment in patients with CKD than renal length.

Keywords:
chronic kidney disease, renal cortical thickness, glomerular filtration rate

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Introduction

Chronic kidney disease (CKD) is a worldwide public health problem, both for the number of patients and cost of treatment involved. Globally, CKD is the 12th cause of death and the 17th cause of disability. This is an underestimate, as patients with CKD are more likely to die of cardiovascular disease than to reach end-stage renal disease [1].

The definition and classification of CKD have evolved over time, but current international guidelines define this condition as decreased kidney function shown by glomerular filtration rate (GFR) of less than 60 ml/min per 1.73 m^2, or markers of kidney damage, or both, of at least 3 months duration, regardless of the underlying cause [2].

Diabetes and hypertension are the leading causes of CKD in all developed and many developing countries, but glomerulonephritis and unknown causes are more common in countries of Asia and sub-Saharan Africa [3].

CKD can be diagnosed by its pathological abnormalities, changes in the levels of kidney function markers in the blood or urine, or by imaging investigations [4].

The diagnosis of CKD rests on establishing a chronic reduction in kidney function and structural kidney damage. The best available indicator of overall kidney function is GFR, which equals the total amount of fluid filtered through all of the functioning nephrons per unit of time [5].

In patients with CKD, renal sonographic dimensional parameters could be of great utility, providing indirect but valuable information about the morphostructural changes occurring in the kidney in the course of CKD. Such information could usefully complement the laboratory investigations commonly performed in the follow-up of the patients with CKD to achieve a more complete assessment of the disease by the combination of functional and morphostructural information [6].

The aim of this study was to determine whether there is a relationship between renal cortical thickness and renal length measured on ultrasound and the degree of renal insufficiency in patients with CKD.

Patients and methods

This cross-sectional study included 50 consecutive stable patients with CKD (32 women and 18 men). The patients were selected from those attending outpatient clinic of renal diseases, Assuit University Hospital, between December 2016 and October 2017. All patients were diagnosed with CKD according to the guidelines of the National Kidney Foundation. Informed consent was obtained from the patients. The research has been approved by the institutional ethics and research committee of the Faculty of medicine, Assiut University, Assiut, Egypt.

Exclusion criteria were any patients of postrenal etiology (e.g., hydronephrosis), patients with autosomal dominant polycystic kidney disease, patients with solitary kidney, patients with acute renal injury, and patients with terminal renal insufficiency undergoing dialysis. Moreover, those with extremes of age, that is, less than 20 years and more than 70 years (have smaller kidney sizes) and patient with extremes of body mass [as equation for estimated glomerular filtration rate (eGFR) do not perform well in such cases].

All participants were subjected to all of the following: (a) detailed information from patients regarding age, sex, duration of diabetes mellitus if diabetic, duration of hypertension if hypertensive, other causes of chronic renal failure was collected, (b) anthropometric data (height and weight, measured as meters and kilograms, respectively) were recorded; (c) renal sonography was done in the same session, and (d) a peripheral blood sample was collected to measure serum creatinine for GFR estimation to stage CKD by the Cockcroft–Gault (CG) equation.

All renal sonographic examinations were performed in the inpatient setting of our Radiology Department. To reduce the intraobserver variability, each measurement was repeated twice in the same session, and the average values were taken into account. The examinations were performed with a 4.0-MHz curvilinear probe and a Medison SonoAce X6 ultrasound machine (Samsung Healthcare Product- Haryana, India).

The following protocol was followed to perform the measurements:

(1) Participants underwent renal sonography in the supine position
(2) Kidney length was measured as the greatest pole-to-pole distance in the sagittal plane, measured in millimeters. Mean renal length was calculated from bilateral measurements
(3) Kidney width was measured as the maximum transverse axis in the hilar region, measured in millimeters. Mean renal width calculated from bilateral measurements
(4) Kidney parenchymal thickness was measured as the distance between the sinus fat and the renal capsule. Kidney parenchymal thickness was obtained at the upper, middle, and lower poles of both kidneys, and the average was calculated to avoid any bias owing to the variability of the border between the echogenic sinus fat and the renal parenchyma
(5) Kidney cortical thickness: the shortest distance from the base of medullary pyramid to the renal capsule in sagittal plane at the level of mid kidney on ultrasound, measured in millimeters. Mean cortical thickness calculated from bilateral measurements
(6) Renal cortical echogenicity was compared and graded with the echogenicity of the liver and renal medulla, according to the following grades:
    (a) Grade 0: normal echogenicity less than that of the liver, with maintained corticomedullary definition
    (b) Grade 1: echogenicity the same as that of the liver, with maintained corticomedullary definition
    (c) Grade 2: echogenicity greater than that of the liver, with maintained corticomedullary definition
    (d) Grade 3: echogenicity greater than that of the liver, with poorly maintained corticomedullary definition
    (e) Grade 4: echogenicity greater than that of the liver, with a loss of corticomedullary definition.

CG equation will be used to eGFR (measured in ml/min/1.73 m^2) from serum creatinine as follows:

CrCl (CG)=(140-age)×lean body weight (kg)×(1.22 male or 1.04 female)/serum creatinine (μ mol/l).

The collected data were revised, organized, tabulated, and statistically analyzed using statistical package for social sciences (SPSS) Version 23.0. Armonk, New York: IBM Corp. , version 23.0 for Windows.

Results

Out of 50 selected patients, 18 (36%) were males and 32 (64%) were females. The patients' age ranged from 20 to 70 years, with a mean age of was 40.6 ± 15.7 years.

The mean renal length was 97.6 ± 12.2 mm, with mean cortical thickness of 9.38 ± 1.79 mm. Of these patients, seven (14.0%) patients had sonographic grade 0 CKD, 25 (50.0%) had grade 1 CKD, and 18 (36.0%) had grade 2 CKD.

The mean serum creatinine level was 2.46 ± 1.74 mg/dl and mean value of eGFR (creatinine clearance) 60.95 ± 53.78 ml/min.

According to eGFR, most of the patients belonged to CKD grade 1 (26%) and grade 4 (26%), 18% had grade 3b, 12% had grade 2, 10% had grade 5, and 8% had grade 3a.

According to the clinical sheets records at renal disease department, the most common known cause of CKD in these patients was systemic lupus, seen in 11 (22%) cases, followed by hypertension in eight (16%) cases, diabetes mellitus in three (6%) cases, diabetes and hypertension together in 4% of cases, in four (8%) cases, the cause was nephrotic syndrome, amyloidosis was the cause in one (2%) case, and another case had CKD after glomerulonephritis. No provisional cause was made in 20 (40%) cases at the time of scanning (Table 1).

Our study showed a high statistically significant relationship between cortical thickness measured at ultrasound and creatinine clearance (r = 0.67, P < 0.001) (Fig. 1).

Moreover, a statistically significant correlation of renal length with creatinine clearance (r = 0.42, P = 0.002) was reported. In Fig. 2, the strongest relationship, as evidenced by the highest Pearson's r value, was for mean cortical thickness and renal impairment (creatinine clearance) than renal length (Table 2). A statistically significant correlation of renal echogenicity grades with creatinine clearance was also reported (Figs. 3-7).

Table 1 Cause of chronic kidney disease in studied patients

Risk factor	Number of patients
SLE	11
Hypertension	8
Diabetes mellitus	3
DM and HT	2
Nephrotic syndrome	4
Amyloidosis	1
Postglomerulonephritis	1
Unknown cause	20

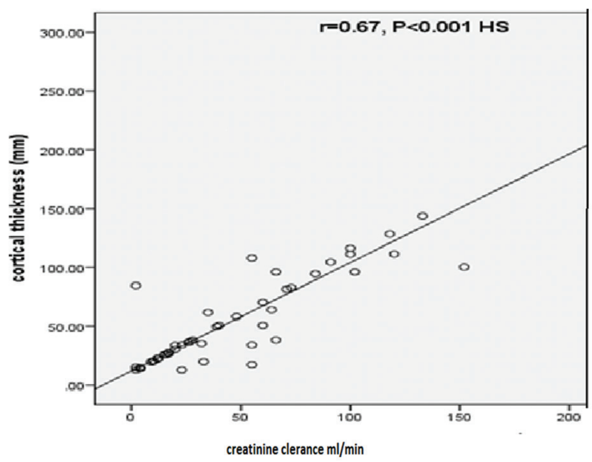
DM, diabetes mellitus; HT, hypertension; SLE, systemic lupus erythematosus.

Table 2 Correlation of cortical thickness, echogenicity grade and renal length measured on ultrasound with the degree of renal impairment in chronic kidney disease

Ultrasonographic measurements	Creatinine clearance (ml/min)	
	r	*P*
Cortical thickness (mm)	0.67	<0.001 (HS)**
Length (mm)	0.42	0.002 (S)*
Echogenicity grades	−0.25	0.023

HS, highly significant; S, significant. **P*<0.05 was considered significant. ***P*<0.001 highly significant.

Figure 1



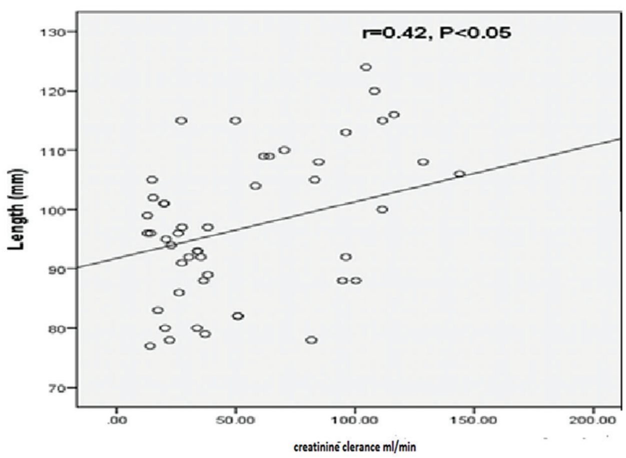
Correlation between cortical thickness and creatinine clearance.

Discussion

In our study, we found that the most common known cause of CKD in these patients was systemic lupus erythematosus in 22%, followed by hypertension in 16%, but another study reported that the most common known cause of CKD in their patients was hypertension (64.5%). The disagreement may be owing to the younger age of most of our patients, as the extremes of age was excluded from our study [7]. Moreover, a study reported that the most common cause of CKD was hypertension in patients [7].

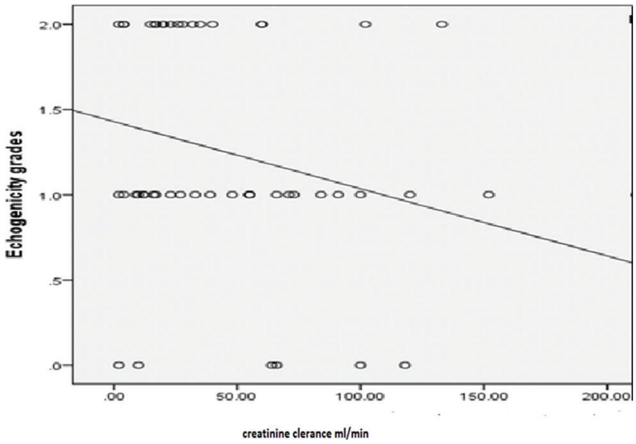
Our study showed a high statistically significant relationship between cortical thickness measured at ultrasound and creatinine clearance (r = 0.67, P < 0.001). Our result was similar to those studies, as they reported a statistically significant positive association between eGFR and mean cortical thickness (r = 0.85, P < 0.01, in the former study and r = 0.508, P < 0.001 in the

Figure 2



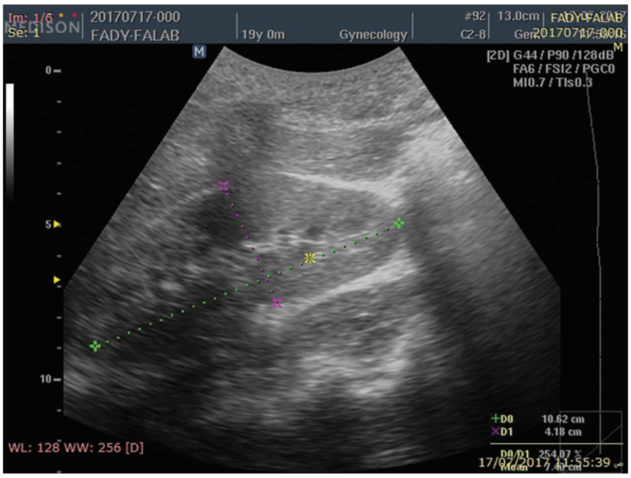
Correlation between renal length and creatinine clearance.

Figure 3



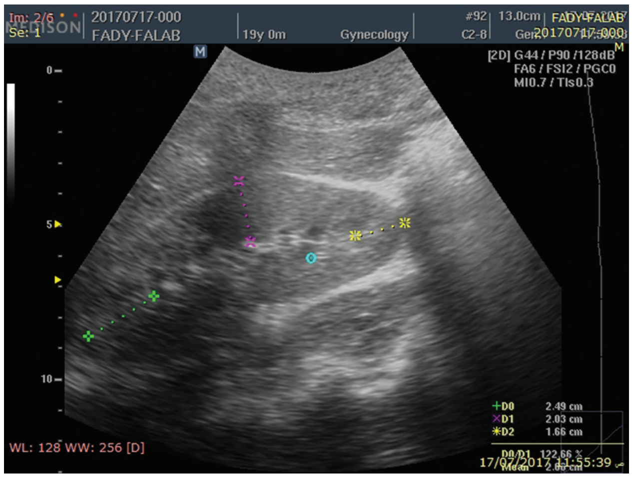
Correlation between echogenicity grades and creatinine clearance.

Figure 4



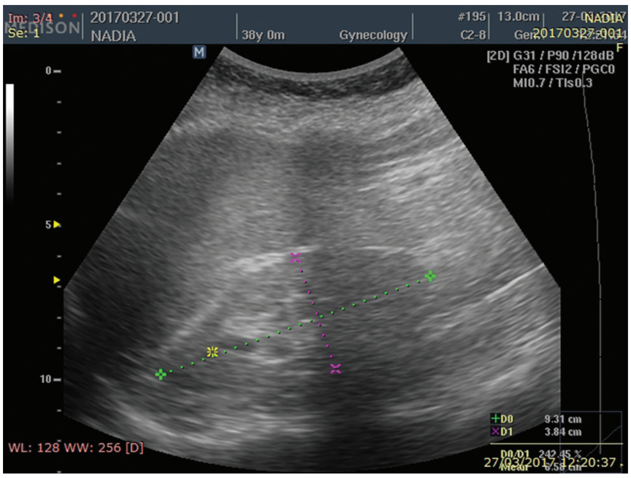
Ultrasound of abdomen shows renal length (106.2 mm), echogenicity grade 1 of right kidney.

Figure 5



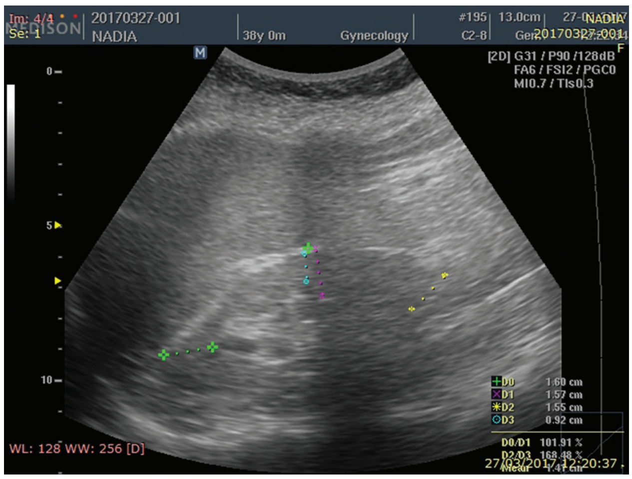
Ultrasound of abdomen shows renal cortical thickness (12.6 mm) of right kidney.

Figure 6



Ultrasound of abdomen shows renal length (93 mm), echogenicity grade 2 of left kidney.

Figure 7



Ultrasound of abdomen show renal cortical thickness (9 mm) of left kidney.

latter study) [7,8]. The same was reported by a study that was carried out on 132 patients with CKD and reported a positive and strong relationship between mean cortical thickness and eGFR [9].

We agreed with the study carried out on 54 patients with CKD, as they reported moderate correlation between measurements of cortical thickness (r = 0.449–0.478, P < 0.001) and renal function impairment [10].

We also agree with the study that was carried out in 200 patients with CKD and reported statistically significant positive and strong relationship between eGFR and mean cortical thickness (r = 0.596, significant P value) [11].

Another study was done and compared the same parameters and also showed a significant correlation between renal cortical thickness and eGFR (r = 0.8) [12].

Our results were also in agreement with a pervious study that was carried out on 25 patients with CKD and reported positive statistically significant relationship between eGFR and cortical thickness (P < 0.0001) [13].

In the present study, we found that there was a statistically significant correlation of renal length with creatinine clearance (r = 0.42, P = 0.002). Similar results as our study was reported (r = 0.66, P < 0.01) [7]. Results by another study also showed poor but still significant correlation between renal function and bipolar length (r = 0.380, P = 0.004) [10].

Our results were also in agreement with studies that reported positive correlation of GFR with kidney length (r = 0.460, P < 0.001, in the former study and P = 0.0029 in the latter study) [13,14].

We also agreed with a study that reported statistically significant and positive, but weak relationship between CG eGFR and mean renal length (r = 0.216, significant P value) [11].

On the contrary, our study disagrees with the results which reported that the renal length did not show a significant relationship with eGFR as suggested by a P value of 0.067; this disagreement may be owing to the most of the study patients had end-stage renal disease [8].

We also found in our study that there was a statistically significant correlation of renal echogenicity grades with creatinine clearance.

We agree with the study that reported statistically significant correlation between eGFR and renal echogenicity grading [9].

In our results, we found that the strongest relationship was for mean cortical thickness and renal impairment (creatinine clearance) than renal length. Similar results have also demonstrated as our study [7,13].

Similar results reported that cortical thickness measured at ultrasound may be related more closely to eGFR than renal length in patients with chronic renal failure [11].

We also agree with the study which reported that correlation between measurements of cortical thickness (r = 0.449–0.478, P < 0.001) and renal function impairment was more significant than correlation between renal function and bipolar length (r = 0.380, P = 0.004) [10].

Our results were also in agreement with the results of the study that reported that renal cortical thickness is the best indicator of renal function in patients with CKD, with a significant and strong relationship between it and renal function in patients with CKD compared with renal length, which showed no significant correlation with renal function [8].

Conclusion

The results of this study have shown that renal cortical thickness measured at ultrasound appears to be more closely related to the degree of renal impairment in patients with CKD than renal length.

Ultrasonography offers a cheap, noninvasive, and easily available method for assessment of renal function in healthy and diseased individuals. So we recommended that routine reporting of cortical thickness should be considered in patients with CKD who are not on dialysis as it is a good indicator for degree of renal impairment in such patients.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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