Original Article

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Correlation of Ultrasonographic Parameters with Serum Creatinine and Estimated Glomerular Filtration Rate in Patients with Echogenic Kidneys

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ABSTRACT

Background: Ultrasonography is widely used to evaluate the kidney status. Serum creatinine and glomerular filtration rate assess the functional status of the kidney. This study tried to find the association between renal parameters in ultrasonography, serum creatinine and estimated glomerular filtration rate in patients with echogenic kidneys.

Methods: Study was done in 61 patients. Four sonographic renal parameters (renal echogenicity grade, renal length, cortical thickness, parenchymal thickness) were obtained from patients showing echogenic kidneys irrespective of cause during ultrasonography of abdomen. Glomerular filtration rate was calculated using Modified Diet in Renal Disease formula after obtaining patient's serum creatinine level. Sonographic renal parameters were compared with serum creatinine and estimated glomerular filtration rate using Pearson's correlation coefficient and one-way ANOVA tests.

Results: The study showed significant correlation of only renal echogenicity grade and parenchymal thickness with eGFR. However, all four sonographic renal parameters showed significant correlation with serum creatinine level. Renal echogenicity grading had strongest correlation with both serum creatinine ($r=0.571$, $p=0.000$) and estimated glomerular filtration rate ($r= -0.349$, $p=0.006$). Mean serum creatinine (in mg/dL) $\pm$ standard deviation was 1.9($\pm$1.5), 4.0($\pm$3.7), 5.8($\pm$3.7), and 15.4($\pm$5.3) for grade I, II, III, and IV echogenic kidneys respectively. Similarly, mean eGFR (in ml/min/1.73m^2) $\pm$ standard deviation was 50.2($\pm$22.9), 35.9($\pm$40), 15.7($\pm$13.4), and 3.4($\pm$1.1) for Grade I, II, III, and IV echogenic kidneys respectively.

Conclusions: Renal echogenicity is a better sonographic parameter that correlated well with both eGFR and serum creatinine. Renal ultrasound should be routinely used for early diagnosis, grading and monitoring of kidney disease.

Keywords: Correlation; estimated glomerular filtration rate; renal echogenicity; serum creatinine; ultrasound

INTRODUCTION

Renal parenchymal disease is a group of diseases of kidney which has been divided broadly into glomerular, vascular and tubulo-interstitial disease. There is considerable overlap between these diseases entities and the end result is renal functional impairment.[1] Renal ultrasonography (USG) is an inexpensive modality with no ionizing radiation and can be done at bedside to provide important details of kidneys with low inter-observer variability.[2,3] Serum creatinine is used to estimate glomerular filtration rate (GFR), which is a primary metric for renal function.[4] Modification of diet in renal disease (MDRD) is one of widely used formulas to calculate estimated GFR (eGFR), which is more accurate and acceptable in evaluating kidney disease.[5]

The aim of the study is to correlate the abnormalities obtained in ultrasonography with serum creatinine and eGFR in Nepalese population and these data could validate the use of renal USG for better diagnosis, management and follow up of patients with renal disease.

METHODS

This prospective, cross-sectional, observational study was carried out in the department of Radiodiagnosis and Imaging, Bir Hospital, Kathmandu, Nepal from November 2018 to October 2019. Following institutional review board approval, a written informed consent was obtained from all the patients meeting the inclusion criteria before undergoing USG of abdomen.

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Patients with bilateral echogenic kidneys in USG within the age group of 20-60 years were included in the study. The exclusion criteria were renal transplant patients, patients under hemodialysis/peritoneal dialysis, patients with ascites, single kidney, post nephrectomy status, renal tumors, obstructive uropathy, and polycystic kidney disease. Convenience sampling technique was used in the study.

The sample size obtained was 61 using the formula $[(Z\alpha + Z\beta)/C]2 + 3$, keeping the significance level for two sided test (α) of 0.05, power of the test (β) of 0.2, expected correlation coefficient (r) of 0.352,[6] standard normal deviation for α (Z_α) of 1.960 and standard normal deviation for β (Z_β) of 0.842. The value of C is obtained using formula $0.5 \times \ln[(1+r)/(1-r)]$.

Patients admitted to emergency department and underwent abdominal USG in department of radiology were included in the study, provided they met inclusion and exclusion criteria. Patient's age, sex and ethnicity were documented before doing USG. They were then made to lie supine or in the contra-lateral decubitus position on examination table for USG with Hitachi Aloka F37 ultrasound machine. Curvilinear (3.5-5 MHz) probe was used, along with ultrasound coupling gel to remove air between abdominal skin and the transducer. Longitudinal, transverse and oblique views were taken with breath holding in mid-inspiration.

Renal length was measured as the greatest pole to pole distance in the sagittal plane. Renal cortical thickness was measured over medullary pyramids, perpendicular to the capsule as the shortest distance from the base of the medullary pyramid to renal capsule in upper pole, inter pole and lower pole and the mean value was taken. Parenchymal thickness was measured between the cortex-perirenal fat interface (capsule) and the sinus-pyramidal apex interface in upper pole, inter pole and lower pole and the mean was taken. Renal cortical echogenicity and cortico-medullary differentiation were evaluated. Bilateral renal cortical echogenicity was compared and graded with echogenicity of the liver or with spleen (in case of fatty liver) and the highest grade among both kidneys was taken in account. They were divided in four grades based on renal echogenicity.[7] In *Grade 1*, renal echogenicity was same as that of the liver with maintained cortico-medullary differentiation. *Grade 2* had renal echogenicity greater than that of the liver with maintained cortico-medullary differentiation. *Grade 3* consisted of renal echogenicity being greater than that of the liver with poorly maintained cortico-medullary differentiation. *Grade 4* had renal echogenicity greater than that of the liver with a loss of cortico-medullary differentiation.

After USG, patient's serum creatinine value obtained from the laboratory of Bir Hospital in fully automated machine named Erba Mannheim XL 300 using Jaffe's reaction was noted. Then eGFR was calculated according to MDRD equation which is eGFR (ml/min per $1.73m^2$) = $175 \times (\text{Serum creatinine in mg/dL})^{-1.154} \times (\text{Age in years})^{-0.203} \times (0.742 \text{ if female}) \times (1.212 \text{ if African American})$.

The data were collected in a structured proforma covering the relevant details. They were then entered in to a SPSS spread sheet and analyzed using SPSS 21 software. Statistical analysis was done using Pearson's correlation coefficient and One-way ANOVA (Post Hoc tests). A 95% confidence interval was taken, and p values of less than 0.05 were termed as statistically significant.

RESULTS

Out of 61 patients, 39 were male (64%) and 22 were female (36%). Male to female ratio was 1.7:1. Maximum number of patients (23 in number, 38%) fell under age group of 51-60 years in which male were 17 in number and female were 6 in number.

On the basis of ultrasonographic grading of echogenicity of kidneys of patients in this study, maximum number (59%) of patients was of grade 2. Similarly 25% of patients were in grade 1 and 11% of patients were of grade 3. The minimum number of patients (5%) was having grade 4 kidneys.

Table 1 shows the serum creatinine level, eGFR and different renal anatomic parameters according to various grades of renal echogenicity.

Table 2 shows the correlation of various sonographic renal parameters with serum creatinine and eGFR level. All four sonographic renal parameters showed significant correlations with serum creatinine. However, only renal echogenicity grading and parenchymal thickness showed significant correlation with eGFR. The renal echogenicity grading had the strongest correlation with both serum creatinine and eGFR. Compared to eGFR, serum creatinine had stronger correlation with renal echogenicity.

Table 1.Serum creatinine and eGFR according to renal echogenicity grades.

Grades of Renal echogenicity	Serum Creatinine (mg/dL)		eGFR(MDRD) ml/ min/1.73m^2		Renal length (mm)		Cortical thickness (mm)		Parenchymal Thickness (mm)	
	Mean± SD	Range	Mean± SD	Range	Mean± SD	Range	Mean± SD	Range	Mean± SD	Range
Grade 1	1.9± 1.5	1.1- 7.5	50.2± 22.9	6.0- 90.7	102.0± 10.1	87- 118	8.5± 0.9	6.6- 10.5	17.0± 2.1	14.3- 20.6
Grade 2	4.0± 3.7	0.5- 17.0	35.9± 40.0	3.62- 21.0	102.5± 11.2	80.5- 121.5	8.5± 1.6	5.4- 12.0	17.2± 3.4	10.5- 26.1
Grade 3	5.8± 3.7	1.7- 13.2	15.7± 13.4	4.1- 44.8	88.7± 10.4	73.5- 104.5	8.2 ± 0.8	6.5- 8.8	15.2± 2.7	12.0- 19.3
Grade 4	15.4± 5.3	10.3- 21.0	3.4± 1.1	2.4- 4.6	67.5± 6.0	60.5- 71.0			8.9± 2.0	7.3± 11.3

Note: In Grade 4 echogenic kidneys, as there was loss of normal cortico-medullary differentiation (CMD), cortical thickness could not be measured.

Table 2.Correlation of serum creatinine and eGFR with various sonographic renal parameters.

Sonographic renal parameters	Serum Creatinine		eGFR	
	P-value	r-value	P-value	r-value
Renal Echogenicity Grading	0.000	0.571**	0.006	-0.349**
Renal Length	0.000	-0.531**	0.112	0.206
Cortical Thickness	0.041	-0.269*	0.203	0.170
Parenchymal Thickness	0.000	-0.501**	0.021	0.294*

*** Correlation is significant at the 0.01 level (2- tailed). * Correlation is significant at the 0.05 level (2- tailed).*

The tendency of line graph in figure 1 showed inverse relationship between the renal echogenicity grading and eGFR. As the grading of renal parenchymal echogenicity increased, the eGFR decreased.

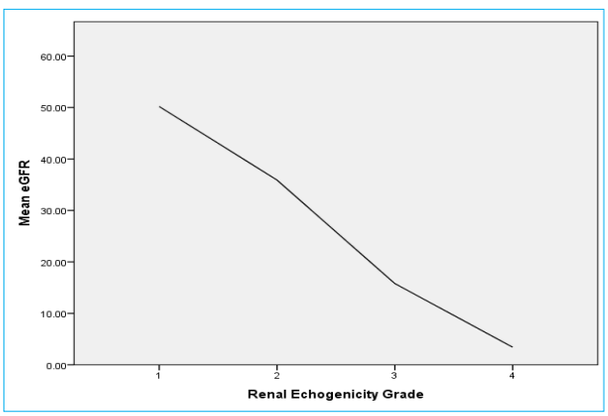

Figure 1.Line graph showing correlation between renal echogenicity grading and mean eGFR.

The line graph in figure 2 shows a linear correlation between the sonographic grading of renal parenchymal echogenicity and serum creatinine. As the renal echogenicity grading increased, there was increase in the serum creatinine level.

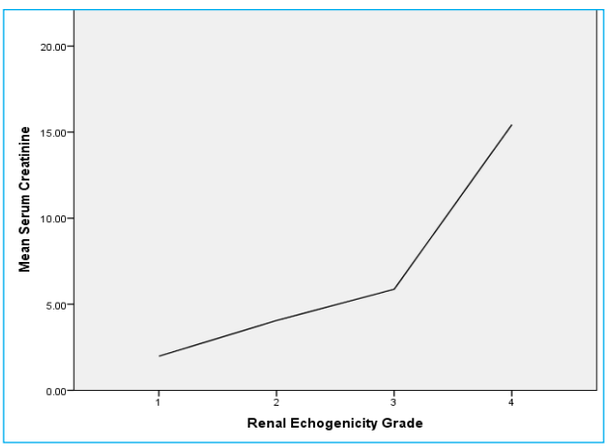

Figure 2.Line graph showing correlation between renal echogenicity grading and mean serum creatinine.

DISCUSSION

In this study, a comparison of different sonographic parameters of kidney, useful for initial evaluation of renal disease was done with the serum creatinine and eGFR, indicators of reserved renal function and prognosis. We used independent diagnostic tools to enhance the accuracy of renal assessment.

Most of the patients in this study were above 50 years of age. Neupane and Lohani[8] in their study also found more than 70% of patients with kidney disease to be above the age of 40 years. In this study, most of the patients with echogenic kidneys were of older age group, representing age as a risk factor for kidney disease, which has also been established in the previous study.[9]

Males (64%) were found to be affected more than females (36%), sex ratio being 1.7:1 in this study. Similarly, renal disease was found more in males (67.1%) compared to females (32.9%) in a study by Shivashankara et al.[10] It may be due to more health seeking behaviour in male in comparison to female.

In this study, most of the patients were having Grade II echogenic kidneys. Singh et al[11] also found highest number of patients with Grade II echogenic kidneys in their study. However, in a study done by Siddappa et al,[7] most of the patients were having Grade I echogenic kidneys. The probable reason for more patients of Grade II compared to Grade I echogenic kidney in this study might be ease in detection of patients having Grade II kidneys with respect to Grade I due to better contrast between echogenicity of liver/spleen and kidneys in the former. So, intra-observer bias during selecting patients might be one reason.

This study compared renal echogenicity grading on ultrasonography with both serum creatinine and eGFR. Significant correlation was found between renal echogenicity grading and serum creatinine level (P=0.000, r=0.571) and between renal echogenicity grading and eGFR level (P=0.006, r= -0.349) with the former being more prominent. So, with the increase in renal echogenicity grade, there was increase in serum creatinine and decrease in eGFR in the study. Shivashankara et al[10] in their studies also found the similar significant association of renal echogenicity grade with serum creatinine and eGFR in their study. In studies done by Siddappa et al,[7] and Singh et al,[11] the grading of renal echogenicity on ultrasonography correlated well with serum creatinine in chronic kidney disease patients. So, the increasing echogenicity may reflect the progressing severity of renal failure and thus having respective increase in serum creatinine and decrease in GFR. Platt et al[12], however found that renal echogenicity similar to liver echogenicity being observed even in the patients with no renal parenchymal disease. This could be due to intra-observer bias while evaluating renal echogenicity for identifying renal parenchymal disease.

In this study, no significant correlation was found between eGFR and renal length and between eGFR and renal cortical thickness. However, previous study by Beland et al[13] found renal cortical thickness to be closely correlated to eGFR, even more than the renal length. Korkmaz et al[14] also found a statistically significant positive correlation between eGFR and mean renal length and between eGFR and mean renal cortical thickness with the latter being more stronger. In this study, the renal length and cortical thickness however showed significant but negative correlation with the serum creatinine level. In a study by Siddappa et al,[7] statistically significant negative correlation was also observed between mean renal longitudinal size and serum creatinine and between mean renal cortical thickness and serum creatinine. The findings of significant negative correlation of renal length and cortical thickness with serum creatinine in this study can be explained by the fact that chronic kidney diseases (thus raised creatinine level) have histological findings of sclerosed glomeruli, tubular atrophy and interstitial fibrosis that can lead to small renal size.[15] Their association with serum creatinine but not with eGFR in the study can be explained by the fact that eGFR here was calculated through MDRD formula, which is based not only on serum creatinine but also on other factors like age, sex and race. Therefore, the same value of eGFR can be normal for one age and sex group but abnormal for another. Another reason could be that our obtained sample might not have all patients of stable chronic renal diseases where MDRD formula is more accurate to calculate eGFR. So, this might have caused some statistical error. Similarly, intra-observer bias while measuring renal length or cortical thickness could be another reason for statistical error.

Renal parenchymal thickness showed significant correlation with both serum creatinine level and eGFR in this study. So, with the decrease in thickness of parenchyma of kidney, there was increase in serum creatinine and decrease in eGFR. Siddappa et al[7] also found significant negative correlation between mean parenchymal thickness and serum creatinine. It can be explained again by the fact that chronic kidney diseases (thus raised creatinine level and low eGFR) have histological findings of sclerosed glomeruli, tubular atrophy, and interstitial fibrosis that can lead to small renal parenchymal thickness.[15] However, no correlation was found between renal parenchymal thickness and serum creatinine level by Singh et al[11] in their study.

There are some limitations in our study. Sample size was less to draw a definite conclusion for general population. The GFR (renal function) was an estimate rather than true measurement. MDRD formula was used to calculate the eGFR in this study. It is only useful in estimating GFR

in stable chronic kidney disease. However in this study, patients with echogenic kidneys were taken irrespective of the causes. So, in the study sample, there might be some patients of acute renal failure too with echogenic kidneys, where MDRD formula couldn't be applied and this might have caused statistical error. Similarly, neither sonography nor eGFR could find out the specific etiology for compromised renal function. Intra-observer bias was another limitation of the study.

CONCLUSIONS

As serum creatinine and eGFR are the indicators of renal function, renal echogenicity in ultrasonography is also a better parameter to estimate the renal function. Renal ultrasound may be used for early diagnosis, grading and monitoring of kidney disease. Ultrasonography of kidney remains a valuable tool for rapid evaluation of renal disease and it should be routinely recommended for any patients suspicious of having renal disease.

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