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SÃO OS PACIENTES COM NEFROPATIA DIABÉTICA DIFERENTES EM RELAÇÃO A PARÂMETROS DE ULTRASSOM RENAL E ACHADOS DE SONOGRAFIA DOPPLER COMPARADOS COM HISTOPATOLOGIA RENAL?

ARE PATIENTS WITH DIABETIC NEPHROPATHY DIFFERENT REGARDING RENAL ULTRASOUND PARAMETERS AND DOPPLER SONOGRAPHY FINDINGS COMPARED WITH RENAL HISTOPATHOLOGY?

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RESUMO

Os achados de ultrassonografia (US) e sonografia Doppler dos vasos renais podem fornecer informações úteis sobre o suprimento estrutural e vascular de pacientes que sofrem de doença renal crônica (DRC). O objetivo deste estudo foi comparar os achados da US de pacientes com nefropatia diabética com os achados patológicos de sua biópsia renal. Neste estudo descritivo, os parâmetros ultrassonográficos, incluindo índice de resistividade (IR), tamanho e volume renal, ecogenicidade cortical e medular e achados histopatológicos da biópsia renal (fibrose, inflamação e cronicidade) de 60 pacientes (27 mulheres e 33 homens) com nefropatia diabética internados no centro renal Hasheminejad (HKC) de Teerã foram extraídos e analisados. Dos 60 pacientes, fibrose intersticial (FI) em 47 pacientes, inflamação intersticial (II) em 50 pacientes e sinais de cronicidade em 43 pacientes no relatório de patologia foram observados. Pacientes com FI apresentaram maior comprimento renal, maior volume sinusal, ecogenicidade grosseira e ecogenicidade medular anormal, significativamente. A presença de II foi associada a maior comprimento renal, maior volume renal e sinusal, maior ecogenicidade cortical e mais pacientes com ecogenicidade grosseira e ecogenicidade medular anormal. A observação da cronicidade foi significativamente correlacionada com maior volume sinusal e mais pacientes com borda renal irregular. De acordo com os achados deste estudo, comprimento e volume renal, volume do seio renal e presença de ecogenicidade grosseira e ecogenicidade medular anormal estão fortemente correlacionados com os achados histopatológicos renais em pacientes com nefropatia diabética. O IR não é um marcador adequado para identificar alterações tubulo-intersticiais nesses pacientes.

Palavras-chave: *Ultrassonografia, Doppler, Índice Resistivo, Doença Renal Crônica, Biópsia renal.*

ABSTRACT

Ultrasonography (US) findings and Doppler sonography of renal vessels can provide useful information on the structural and vascular supply of patients suffering from chronic kidney disease (CKD). The purpose of this study was to compare the US findings of patients with diabetic nephropathy with the pathologic findings of their renal biopsy. In this descriptive study, US parameters including resistivity index (RI), renal size and volume and cortical and medullary echogenicity, and histopathological findings of renal biopsy (fibrosis, inflammation and chronicity) of 60 patients (27 women and 33 men) with diabetic nephropathy admitted in Hasheminejad kidney center (HKC) of Tehran were extracted and analyzed. Of 60 patients, interstitial fibrosis (IF) in 47 patients, interstitial inflammation (II) in 50 patients and signs of chronicity in 43 patients in pathology report were observed. Patients with IF had larger renal length, higher sinus volume, coarse echogenicity, and abnormal medullary echogenicity, significantly. The presence of II was associated with larger renal length, higher renal and sinus volume, higher cortical echogenicity, and more patients with coarse echogenicity and abnormal medullary echogenicity. The observation of chronicity was significantly correlated with higher sinus volume and more patients with irregular renal rim. According to the findings of this study, renal length and volume, renal sinus volume, and the presence of coarse echogenicity and abnormal medullar echogenicity strongly correlate with renal histopathologic findings in patients with diabetic nephropathy. RI is not a suitable marker for identifying tubulointerstitial changes in these patients.

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Keywords: *Ultrasonography, Doppler Ultrasound, Resistive Index, Chronic Kidney Disease, Renal biopsy.*

1. INTRODUCTION

Chronic kidney disease (CKD) is one of the major growing issues in the public health system, worldwide (Nahas and Bello, 2005). Only a small population of patients with renal dysfunction experience a rapid decline in renal function and often they are presented with a chronic impairment of renal function (Eriksen and Ingebretsen, 2006). Diabetes mellitus (DM) is one of the main causes of CKD, other health problems and diabetic nephropathy is the most common cause of end-stage renal disease (ESRD) (Ritz and Orth, 1999, Ghajari et al., 2017). The diagnosis of CKD in patients with DM and the prognosis of it, especially their long-term prognosis is of great importance. The major predictors of renal function decline in these patients are arterial hypertension (HTN), proteinuria, and baseline renal function (Bigé et al., 2012). Histological findings of renal biopsy, including the presence of interstitial fibrosis (IF) are also associated with renal function and long-term prognosis of CKD (Nath, 1992).

Ultrasonography (US) findings and Doppler sonography of renal vessels can provide useful information on the structural and vascular morphology of patients suffering from CKD. Unlike histopathologic studies, US is a non-invasive method to evaluate patients who are at risk of renal impairment (Ghadirpour et al., 2014). Several studies in recent years have shown the relationship between US parameters (especially renal resistive index (RI)) and tubulointerstitial and vascular damage of the kidneys (Sugiura and Wada, 2009).

Despite the promising results in various studies, US parameters are less used in CKD management (Buturović-Ponikvar and Višnar-Perovič, 2003). The aim of the study was to compare the sonographic findings of patients with diabetic nephropathy with the pathologic findings of the renal biopsy in these patients so that this low-risk and safe method can be used as an alternative to more risky diagnostic methods such as biopsy and imaging with contrast media.

2. MATERIALS AND METHODS

2.1 Study design and setting

This descriptive cross-sectional study was performed from October to May in 2017-2018. The study was done at Hasheminejad Kidney Center (HKC), a referral academic hospital affiliated to Iran University of Medical Sciences, Tehran and was approved by the ethics committee (code#: IR.IUMS.FMD.REC.1396.9411282017) of Iran University of Medical Sciences. The research was carried out according to the Helsinki Declaration and informed written consent was obtained from all participants.

2.2. Participants

This study included 60 patients with DM referred to the Hasheminejad kidney center (HKC) for renal biopsy. History and demographic information were taken from all participants.

The inclusion criteria were:

1. Patients with diabetic nephropathy (proteinuria > 0.5 g/24h) (Gross et al., 2005)
2. Age > 20 years

The exclusion criteria were:

1. Polycystic kidney disease
2. Post-renal CKD
3. Acute kidney injury
4. Patients with one kidney
5. Renal tumors
6. Asymmetry of the kidneys (> 2 cm difference in renal length)

2.3 Ultrasonographic and histopathologic evaluation

US examination was performed 24 hours before the renal biopsy. U.S and Doppler US examinations were performed by a single radiologist with 10 years biopsy experience unaware of patient information, by a 3.5 MHz abdominal convex transducer with a PHILIPS Acuson 500. For each patient, renal length, volume, renal sinus volume, and cortical and medullary thickness was measured for both kidneys. Renal cortical echogenicity was assessed and recorded as Grade 1, 2 and 3, as

being light, moderate, and advanced, respectively (Gross et al., 2016). Corticomedullary differentiation and medullary echogenicity were evaluated as normal, increased and decreased. The presence of coarse echogenicity was also evaluated (normal, slightly or considerable). Renal rim was recorded as either regular or irregular. The presence of inflammatory changes, surrounding fat, fatty infiltration of the renal parenchyma, and renal displacement during inhalation was also recorded. RI was calculated by the following formula using built-in software: (systolic flow velocity - diastolic flow velocity) / systolic flow velocity. The RI was measured five times on each kidney and the average value was recorded (Kim et al., 1992).

Renal biopsies were performed by using ultrasonographic localization of the lower pole of the left kidney. All renal biopsy specimens were reviewed on light microscopy, immunofluorescence, and electron microscopy (Ikee et al., 2005; Spyridopoulos et al., 2010). The presence of renal interstitial fibrosis (IF), interstitial inflammation (II) and chronicity were evaluated.

2.4 Statistical analysis

Statistical analysis was performed by SPSS software V22, SPSS Inc., Chicago, IL, USA. The Kolmogorov-Smirnov test was used to assess the normality of the data distribution. Chi-square test and repeated measures ANOVA were used for statistical comparison of results between. The significant threshold was considered to be less than 0.05.

3. RESULTS AND DISCUSSION:

Of 60 patients enrolled in this study, 27 (45%) were female and 33 (55%) were male (Table 1). Of these patients, we observed interstitial fibrosis (IF) in 47, interstitial inflammation (II) in 50 and signs of chronicity in 43 patients. As it is demonstrated in table 2-4, there were no significant differences in the sex distribution, mean age and the number of patients with HTN between cases with the presence of either histopathologic finding and patients without them (all with p-value > 0.05). The mean age of patients with IF in their renal specimen and without it, was 49.91 ± 15.13 43.00 ± 13.00 years, respectively. The mean age of patients with II was 49.14 ± 14.99 years and in cases without II was 44.80 ± 14.48 years. In patients with positive findings regarding chronicity, the mean age was 49.26 ± 15.67 years and in patients with negative findings, it was 46.29 ± 12.82 years. The glomerular filtration rate (GFR) values were significantly lower in patients with positive findings in their renal biopsy all with p-value < 0.001 (35.72 ± 12.32, 37.18 ± 26.00 and 35.02 ± 27.06 in patients with IF, II and chronicity compared to 79.00 ± 12.32, 84.70 ± 6.46 and 70.59 ± 19.62 in patients without them, respectively).

In table 2, US findings are demonstrated based on the presence of interstitial fibrosis in the renal biopsy. As it is shown, there was no significant difference in renal volume, RI, renal cortex, medulla and cortex on medulla thickness, medulla/cortex and parenchyma/renal diameter ratio, cortex echogenicity, Corticomedullary differentiation, renal rim contour and the presence of inflammatory changes, surrounding fat, fatty infiltration of the renal parenchyma, and renal displacement during inhalation, whether IF was present or not. The RI was higher in patients with fibrosis (0.68 ± .11 and 0.67 ± .10 compared to 0.65 ± .02 and 0.65 ± .03 in right and left kidney, respectively) with no significant difference (both with p-value = 0.401). Patients with fibrosis had a larger right kidney (111.02 ± 9.40 mm compared to 104.15 ± 4.34 mm) with p-value = 0.020. The sinus volume was 33.84 ± 12.10 cc in right kidney and 35.30 ± 11.28 cc in the left kidney in patients with IF and 23.77 ± 8.56 cc in right kidney and 22.54 ± 9.23 cc in left kidney in patients without IF. This difference was significant (p-value = 0.007 and 0.004, respectively). The fibrosis was associated with more patients with renal coarse echogenicity (17 cases of slight and 6 cases of considerable coarse echogenicity compared to none in patients without IF) and abnormal medullar echogenicity (15 patients with decreased and 7 with increased echogenicity, whereas all of the patients without fibrosis were normal regarding this US parameter) with p-value = 0.006 and 0.008, respectively.

In table 3, US findings are shown based on the presence of interstitial inflammation in the renal biopsy. We observed no significant difference comparing patients with II and patients without it, regarding RI, renal cortical, medullar and cortex on medulla thickness, medulla to cortex and parenchyma to diameter ratio, Corticomedullary differentiation, renal rim contour and the presence of inflammatory changes, renal surrounding fat, fatty infiltration of the renal parenchyma, and renal displacement during inhalation. The RI was 0.68 ± .10 and 0.65 ± .03 in the right kidney and 0.66 ± .10 and 0.65 ± .03 in the left kidney, in patients with and without

inflammation, respectively, with no significant difference (both with p-value = 0.611). The presence of inflammation was associated with larger kidney and larger renal volume, significantly (111.02 ± 9.11 mm and 196.88 ± 50.02 cc compared to 102.10 ± 2.18 mm and 134.30 ± 17.48 cc in right and 110.76 ± 11.32 mm and 192.92 ± 75.71 cc compared to 103.00 ± 4.83 mm and 139.50 ± 10.29 cc in left kidney) all with p-value < 0.05. The sinus volume was 33.79 ± 11.71 cc in right kidney and 35.21 ± 10.91 cc in left kidney in patients with II and 21.00 ± 7.79 cc in right kidney and 19.10 ± 7.53 cc in left kidney in patients without inflammation. This difference was significant (p-value = > 0.001 and 0.001, respectively). The coarse echogenicity was recorded only in patients with inflammation (17 cases of slight and 6 cases of considerable coarse echogenicity) which was significant with p-value =0.024. Patients with increased cortical echogenicity (17 grade 2 and 7 grade 3) and abnormal medulla echogenicity (15 patients with decreased and 7 with increased echogenicity) were also observed only in the case of II, with p-value = 0.018 and 0.031, respectively.

In table 4, US findings are demonstrated based on the presence of chronicity in the renal biopsy. There was no significant difference comparing patients with and without chronicity regarding RI, renal medullar thickness, medulla to cortex and parenchyma to diameter ratio, cortical and medullar echogenicity, Corticomedullary differentiation, and the presence of inflammatory changes, renal surrounding fat, fatty infiltration of the renal parenchyma, and renal displacement during inhalation. The RI was higher in the presence of chronicity with no significant difference (0.68 ± .11 and 0.65 ± .04 in the right kidney and 0.67 ± .11 and 0.64 ± .03 in the left kidney, with p-value = 0.219 and 0.84, in patients with and without chronicity, respectively (Table 5). The presence of chronicity was also associated with larger kidney and larger renal volume, significantly (112.05 ± 9.18 mm and 198.00 ± 40.74 cc compared to 103.18 ± 4.17 mm and 157.24 ± 65.20 cc in right and 112.28 ± 11.11 mm and 196.33 ± 71.72 cc compared to 102.35 ± 6.15 mm and 152.88 ± 64.49 cc in left kidney) all with p-value < 0.05. The sinus volume was 34.92 ± 12.18 cc in right and 36.22 ± 11.42 cc in the left kidney in patients with chronicity and 23.59 ± 7.42 cc in right and 23.35 ± 8.14 cc in left kidney in patients without chronicity. This difference was significant both with p-value < 0.001. Higher cortical thickness was observed in patients with positive chronicity in renal biopsy in both kidneys (8.69 ± 2.67 mm and compared to 7.46 ± 1.18 mm in right and 9.48 ± 5.93 mm compared to 7.13 ± .42 mm in left) with p-value = 0.046 and 0.004, respectively. The thickness of the portion of cortex lying on medulla was also higher in patients with chronicity sign which was significant in the left kidney (8.21 ± 1.99 mm and compared to 7.11 ± .45 mm with p-value = 0.004) (Table 6). The coarse echogenicity and irregular renal rim contour were observed only in patients with chronicity (17 cases of slight and 6 cases of considerable coarse echogenicity and 10 patients with irregular rim) with p-value =0.001 and 0.025, respectively (Table 7).

U.S is a useful diagnostic tool in nephrology conditions. In many of the renal disorders, US is used as the first line of diagnosis, due to its non-invasive nature and its low cost and the ability to evaluate different parts of the kidney and its parenchyma (Lucisano et al., 2015). However, it is still less used in evaluating the structural changes and management of CKD (Pellerito and Polak, 2012). The aim of this study was to investigate the relationship between US findings and renal histopathology in patients with diabetic nephropathy.

Based on the findings of this study, the interstitial fibrosis was associated with larger kidney, higher renal sinus volume, and more patients with coarse echogenicity and abnormal medullar echogenicity (i.e. decreased or increased). The presence of interstitial inflammation in the renal biopsy had a significant relationship with larger kidney, larger renal and sinus volume, higher cortical echogenicity, and more patients with coarse echogenicity and abnormal medullar echogenicity (i.e. decreased or increased). The observation of chronicity was significantly correlated with larger kidney, higher cortical thickness, higher renal sinus volume, and more patients with irregular renal rim contour and coarse echogenicity. There was no significant difference between the pathologic findings of the renal biopsy specimen of patients with diabetic nephropathy and their mean RI.

Moghazi et al. conducted a study regarding the relationship of US findings with renal histopathological findings in 207 patients with CKD (Moghazi et al., 2005). They concluded that among US parameters, cortical echogenicity associated best with the renal histopathology. There was a significant correlation between renal size and glomerular sclerosis and tubular atrophy and between parenchyma thickness and tubular atrophy. Furthermore, the most important determinants of cortical echogenicity were tubular atrophy and interstitial inflammation and not the

fibrosis. In 86% of patients in higher grades of CKD, renal length of < 20 cm and cortical echogenicity > 1 were recorded. They reported that even though size or echogenicity alone are not adequate factors in diagnosing the irreversible chronic renal disease, but the probability of a curable disease in patients with smaller kidney and higher cortical echogenicity is very low. In comparison, in the present study, higher renal size and sinus volume and the presence of coarse echogenicity were associated with all of the renal histopathologic findings (i.e. fibrosis, inflammation, and chronicity). Also, there was no comparison between the severity of renal function and size. Similar to the Moghazi et al. study, there was an association between cortical echogenicity and interstitial inflammation and not the interstitial fibrosis. The lack of correlation between interstitial fibrosis and cortical echogenicity seems surprising, Given that it is widely assumed that collagen fibrils play an important role in acoustic backscatter of tissue (Rosenfield et al., 1978; Insana et al., 1991; Price et al., 1980). In another study conducted by Hricak et al. on the qualitative assessment of echogenicity (Hricak et al., 1982), no relation was found with IF.

In a Lucisano et al. study on 72 patients with stages 1-4 of CKD (Lucisano et al., 2015), it was found that parenchymal thickness and renal length were highly correlated with GFR and could be appropriate tools for evaluating renal function in these patients. Based on the findings of this study, correction of US parameters with the height of patients would strengthen the association of these parameters with the GFR. In the Hricak et al. study, a relationship was also observed between renal length and histopathologic findings including sclerosis (Hricak et al., 1982). On the other hand, Beland et al. concluded that cortical thickness compared with renal length is a better indicator of renal function and it has a stronger relationship with GFR (Beland et al., 2010). In the present study, renal length was associated with interstitial fibrosis, inflammation, and chronicity in renal biopsy of patients with diabetic nephropathy.

Van et al. also showed that both renal length and volume are associated with renal function measured by GFR in the elderly, but the renal length has low specificity in the prediction of renal impairment (Van et al., 2013). The main problem with measuring renal volume using ultrasound is the difficulty in measuring the true renal volume due to using of the ellipsoid formula to measure the renal volume, while the kidney is not a true ellipsoid.

In our study, cortical thickness was only associated with chronicity and not the presence of inflammation or interstitial fibrosis. Furthermore, medulla thickness was not significantly correlated with any of the renal histopathologic findings. In the Moghazi et al. study, there was no correlation between renal parenchymal and cortical thickness and pathologic findings (Moghazi et al., 2005). The poor correlation of histopathological findings with these measurements may be due to the poor accuracy and reproducibility of these parameters. Also, in the presence of poor Corticomedullary differentiation, such as patients with moderate to advanced CKD, the cortex and medulla interface is hard to evaluate and it is more appropriate to measure the parenchymal thickness (sum of cortex and medulla), instead (Beland et al., 2010).

In Yaprak et al. study, a different method was used to evaluate renal function. In this study, renal length and parenchymal thickness and echogenicity were calculated and summed up as a CKD ultrasound score (Yaprak et al., 2017). It was concluded that there is a correlation between CKD ultrasound score and eGFR and this score can be used to differentiate between grades 3-5 and 1-2 of CKD. Relationships between RI and several pathological renal conditions such as glomerulosclerosis and tubulointerstitial and vascular injuries, as well as diabetes have been reported in some studies (Bakker et al., 1999; Moradi et al., 2011; Hedayatifar et al., 2017, Shirin et al., 2016, Sugiura et al., 2016; Mostbeck et al., and Platt et al., 1990).

Despite the strength of the present study, it is subject to a number of limitations and should be interpreted in view of its limitations. The main limitation was the small sample size. Also, US parameters were not compared with renal function markers including creatinine and GFR. Furthermore, RI was not analyzed in different stages of nephropathy.

4. CONCLUSIONS:

According to the findings of this study, renal length and volume, renal sinus volume, and the presence of coarse echogenicity and abnormal medullar echogenicity strongly correlate with renal histopathologic findings (presence of fibrosis, inflammation, and chronicity) in patients with diabetic nephropathy. Also, RI is not a suitable marker for identifying

tubulointerstitial changes in these patients. Increased cortical echogenicity and thickness are associated with interstitial inflammation and chronicity, respectively.

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6. CONFLICTS OF INTEREST:

No conflicts are declared

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Table 1. *Patients' sex distribution*

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Female	27	45.0	45.0	45.0
Male	33	55.0	55.0	100.0
Total	60	100.0	100.0	-

Table 2. *Ultrasonography findings based on the presence of interstitial fibrosis in the renal biopsy*

Characteristic	Without fibrosis	With fibrosis	P-value
No.	13	47	
Age (y)	43.00 (13.00)	49.91 (15.13)	.116
GFR (ml/min)	79.00 (12.32)	35.72 (12.32)	< .001
Sex			
Female	7 (53.8)	20 (42.6)	.469
Male	6 (46.2)	27 (57.4)	
Hypertension			
No	6 (46.2)	21 (44.7)	.925
Yes	7 (53.8)	26 (55.3)	
Renal volume (RK) (cc)	170.23 (69.94)	190.94 (45.42)	.083
Renal volume (LK) (cc)	171.92 (62.25)	187.36 (74.70)	.253
Renal sinus volume (RK) (cc)	23.77 (8.56)	33.84 (12.10)	.007
Renal sinus volume (LK) (cc)	22.54 (9.23)	35.30 (11.28)	.004
Renal length (RK) (mm)	104.15 (4.34)	111.02 (9.40)	.020
Renal length (LK) (mm)	104.62 (5.19)	110.81 (11.69)	.070
RI (RK)	.65 (.02)	.68 (.11)	.401
RI (LK)	.65 (.03)	.67 (.10)	.464
Cortex thickness (RK) (mm)	8.00 (.71)	8.43 (2.69)	.891
Cortex thickness (LK) (mm)	7.23 (.44)	9.25 (5.72)	.098
Medulla thickness (RK) (mm)	8.54 (1.42)	8.00 (2.35)	.687
Medulla thickness (LK) (mm)	8.46 (2.13)	8.54 (3.30)	.588
Cortex on medulla thickness (RK) (mm)	8.00 (.71)	8.35 (2.09)	.805
Cortex on medulla thickness (LK) (mm)	7.23 (.44)	8.08 (1.94)	.098
Medulla/cortex (RK)	1.15 (.39)	.97 (.32)	.163
Medulla/cortex (LK)	1.17 (.32)	.98 (.25)	.107
Parenchyma/diameter (RK)	.69 (.38)	.63 (.64)	.408
Parenchyma/diameter (LK)	.68 (.37)	.61 (.61)	.596

*GFR: Glomerular filtration rate, RK: Right kidney, LK: left kidney, RI: Resistive index

Table 3. *Ultrasonography findings based on the presence of interstitial fibrosis in the renal biopsy*

Characteristic	**Without fibrosis**	**With fibrosis**	**P-value**
Cortex echogenicity, No (%)			
Grade 1	10 (76.9)	26 (55.3)	
Grade 2	3 (23.1)	14 (29.8)	.236
Grade 3	0 (0)	7 (14.9)	
Coarse echogenicity, No (%)			
Normal	13 (100)	24 (51.1)	
Slightly	0 (0)	17 (36.2.3)	.006
Considerable	0 (0)	6 (12.8)	
Inflammatory changes, No (%)			
No	0 (0)	7 (14.9)	.139
Yes	13 (100)	40 (85.1)	
Medulla echogenicity, No (%)			
Normal	13 (100)	25 (53.2)	
Decreased	0 (0)	15 (31.9)	.008
Increased	0 (0)	7 (14.9)	
Corticomedullary differentiation, No (%)			
Normal	3 (23.1)	10 (21.3)	
Decreased	0 (0)	11 (23.4)	.146
Increased	10 (76.9)	26 (55.3)	
Renal rim, No (%)*			
Regular	13 (100)	37 (78.7)	.068
Irregular	0 (0)	10 (21.3)	
Fat surrounding the kidney, No (%)			
No	10 (100)	41 (87.2)	.232
Yes	0 (0)	6 (12.8)	
Fatty infiltration of the renal parenchyma, No (%)			
No	10 (100)	40 (85.1)	.193
Yes	0 (0)	7 (14.9)	
Renal displacement during inhalation, No (%)			
No	10 (100)	44 (93.6)	.412
Yes	0 (0)	3 (6.4)	

Table 4. *Ultrasonography findings based on the presence of interstitial inflammation in the renal biopsy*

Characteristic	Without inflammation	With inflammation	P-value
No.	10	50	
Age (y)	44.80 (14.48)	49.14 (14.99)	.564
GFR (ml/min)	84.70 (6.46)	37.18 (26.00)	< .001
Sex, No (%)			
Female	7 (70)	20 (40)	.082
Male	3 (30)	30 (60)	
Hypertension, No (%)			
No	6 (60)	21 (42)	.296
Yes	4 (40)	29 (58)	
Renal volume (RK) (cc)	134.30 (17.48)	196.88 (50.02)	< .001
Renal volume (LK) (cc)	139.50 (10.29)	192.92 (75.71)	.011
Renal sinus volume (RK) (cc)	21.00 (7.79)	33.79 (11.71)	.001
Renal sinus volume (LK) (cc)	19.10 (7.53)	35.21 (10.91)	< .001
Renal length (RK) (mm)	102.10 (2.18)	111.02 (9.11)	< .001
Renal length (LK) (mm)	103.00 (4.83)	110.76 (11.32)	.018
RI (RK)	.65 (.03)	.68 (.10)	.611
RI (LK)	.65 (.03)	.66 (.10)	.611
Cortex thickness (RK) (mm)	8.30 (.48)	8.35 (2.63)	.586
Cortex thickness (LK) (mm)	7.30 (.48)	9.11 (5.56)	.245
Medulla thickness (RK) (mm)	7.80 (.26)	8.18 (2.39)	.311
Medulla thickness (LK) (mm)	7.40 (.77)	8.75 (3.30)	.402
Cortex on medulla thickness (RK)	8.30 (.48)	8.27 (2.05)	.585
Cortex on medulla thickness (LK) (mm)	7.30 (.48)	8.01 (1.90)	.245
Medulla/cortex (RK)	.94 (.04)	1.02 (.37)	.874
Medulla/cortex (LK)	1.01 (.09)	1.03 (.30)	.937
Parenchyma/diameter (RK)	.80 (.37)	.61 (.62)	.080
Parenchyma/diameter (LK)	.79 (.35)	.59 (.60)	.131

*GFR: Glomerular filtration rate, RK: Right kidney, LK: left kidney, RI: Resistive index

Table 5. *Ultrasonography findings based on the presence of interstitial inflammation in the renal biopsy*

Characteristic	Without inflammation	With inflammation	P-value
Cortex echogenicity, No (%)			
Grade 1	10 (100)	26 (52)	
Grade 2	0 (0)	17 (34)	.018
Grade 3	0 (0)	7 (14)	
Coarse echogenicity, No (%)			
Normal	10 (100)	27 (54)	
Slightly	0 (0)	17 (34)	.024
Considerable	0 (0)	6 (12)	
Inflammatory changes, No (%)*			
No	0 (0)	7 (14)	.208
Yes	10 (100)	43 (86)	
Medulla echogenicity, No (%), No (%)*			
Normal	10 (100)	28 (56)	
Decreased	0 (0)	15 (30)	.031
Increased	0 (0)	7 (14)	
Corticomedullary differentiation, No (%)			
Normal	3 (30)	10 (20)	
Decreased	0 (0)	11 (22)	.249
Increased	7 (70)	29 (58)	
Renal rim, No (%)*			
Regular	10 (100)	40 (80)	.121
Irregular	0 (0)	10 (20)	
Fat surrounding the kidney, No (%)*			
No	7 (100)	44 (88)	.333
Yes	0 (0)	6 (12)	
Fatty infiltration of the renal parenchyma, No (%)*			
No	7 (100)	43 (86)	.291
Yes	0 (0)	7 (14)	
Renal displacement during inhalation, No (%)*			
No	7 (100)	47 (94)	.506
Yes	0 (0)	3 (6)	

Table 6. *Ultrasonography findings based on the presence of chronicity in the renal biopsy*

Characteristic	Without chronicity	With chronicity	P-value
No.	17	43	
Age (y)	46.29 (12.82)	49.26 (15.67)	.297
GFR (ml/min)	70.59 (19.62)	35.02 (27.06)	< .001
Sex, No (%)			
Female	11 (64.7)	16 (37.2)	.054
Male	6 (35.3)	27 (62.8)	
Hypertension, No (%)			
No	6 (35.3)	21 (48.8)	.342
Yes	11 (64.7)	22 (51.2)	
Renal volume (RK) (cc)	157.24 (65.20)	198.00 (40.74)	.001
Renal volume (LK) (cc)	152.88 (64.49)	196.33 (71.72)	.004
Renal sinus volume (RK) (cc)	23.59 (7.42)	34.92 (12.18)	< .001
Renal sinus volume (LK) (cc)	23.35 (8.14)	36.22 (11.42)	< .001
Renal length (RK) (mm)	103.18 (4.17)	112.05 (9.18)	< .001
Renal length (LK) (mm)	102.35 (6.15)	112.28 (11.11)	.001
RI (RK)	.65 (.02)	.68 (.11)	.219
RI (LK)	.64 (.03)	.67 (.11)	.084
Cortex thickness (RK) (mm)	7.46 (1.18)	8.69 (2.67)	.046
Cortex thickness (LK) (mm)	7.13 (.42)	9.48 (5.93)	.004
Medulla thickness (RK) (mm)	7.82 (1.81)	8.23 (2.32)	.299
Medulla thickness (LK) (mm)	8.05 (2.00)	8.72 (3.40)	.817
Cortex on medulla thickness (RK) (mm)	7.76 (.75)	8.48 (2.15)	.259
Cortex on medulla thickness (LK) (mm),	7.11 (.45)	8.21 (1.99)	.004
Medulla/cortex (RK)	1.10 (.35)	.97 (.33)	.160
Medulla/cortex (LK)	1.13 (.28)	.98 (.26)	.227
Parenchyma/diameter (RK)	.59 (.39)	.67 (.65)	.375
Parenchyma/diameter (LK)	.59 (.37)	.64 (.63)	.445

*GFR: Glomerular filtration rate, RK: Right kidney, LK: left kidney, RI: Resistive index

Table 7. *Ultrasonography findings based on the presence of chronicity in the renal biopsy*

Characteristic	Without chronicity	With chronicity	P-value
Cortex echogenicity, No (%)			
Grade 1	10 (58.8)	26 (60.5)	
Grade 2	7 (41.2)	10 (23.3)	.125
Grade 3	0 (0)	7 (16.3)	
Coarse echogenicity, No (%)			
Normal	17 (100)	20 (46.5)	
Slightly	0 (0)	17 (39.5)	.001
Considerable	0 (0)	6 (14)	
Inflammatory changes, No (%)*			
No	0 (0)	7 (16.3)	.077
Yes	17 (100)	36 (83.7)	
Medulla echogenicity, No (%), No (%)*			
Normal	13 (76.5)	25 (58.1)	
Decreased	4 (23.5)	11 (25.6)	.180
Increased	0 (0)	7 (16.3)	
Corticomedullary differentiation, No (%)			
Normal	3 (17.6)	10 (23.3)	
Decreased	4 (23.5)	7 (16.3)	.767
Increased	10 (58.8)	26 (60.5)	
Renal rim, No (%)*			
Regular	17 (100)	33 (76.7)	.025
Irregular	0 (0)	10 (23.3)	
Fat surrounding the kidney, No (%)*			
No	14 (100)	37 (86)	.140
Yes	0 (0)	6 (14)	
Fatty infiltration of the renal parenchyma, No (%)*			
No	14 (100)	36 (83.7)	.122
Yes	0 (0)	7 (16.3)	
Renal displacement during inhalation, No (%)*			
No	14 (100)	40 (93)	.310
Yes	0 (0)	3 (7)	