

Original Research Article

Doppler Study of Transplanted Kidney, Follow Up at CKD & Urology Hospital, Dhaka, Bangladesh

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Abstract: **Introduction:** Renal transplantation is the treatment of choice for managing patients with end-stage kidney disease. Being submitted to a very serious surgical procedure, renal transplant recipients can only benefit from follow-up imaging and monitoring strategies. Duplex study is considered as the principal imaging test in the evaluation of renal transplants. **Objective:** To assess the doppler study of transplanted kidney follow up at CKD & Urology Hospital, Dhaka, Bangladesh. **Materials and Methods:** The Duplex study was conducted at Dept. of Radiology and Imaging, CKD & Urology Hospital, Dhaka, Bangladesh from January to April 2022. Fifty patients (36 males and 14 females) who underwent renal transplantation were included. Their ages ranging from 16-60 years; they all subjected to ultrasound, color Doppler and histopathology. All patients underwent clinical evaluation as well as biochemical and radiological examination in the post-transplant period. They were evaluated on gray scale and color Doppler as a protocol on the 5th, 14th and 30th post-operative day. They were also evaluated as and when clinical suspicion of graft dysfunction was raised. **Results:** A total of 50 renal transplant recipients were included in this study. Most number of patients, 12 (40%) were in the 30-39 years age group. There were 36 male and 14 female patients. 50 patients (100%) presented with a rise in serum creatinine. 4 patients (8%) presented with tenderness and swelling over transplanted kidney. 7 patients (14%) presented as uncontrolled hypertension. There were seven patients who developed chronic rejection (14%). Transplant renal artery stenosis was detected in 2 cases (4%). One case each of renal artery thrombosis (2%) were encountered. Peritransplant fluid collections were seen in 20 patients (40%). 2 patients (4%) developed post biopsy arteriovenous fistulas. 14 patients (28%) had small post op collections without any graft dysfunction. All of them showed regression on follow up scans. Their location was variable and they appeared cystic in appearance. Acute rejection was seen in 1 cases (2%) and Chronic rejection 4(8%) and Normal 45(90%). Five cases of cyclosporine toxicity (10%) and one case of ATN (2%) were encountered. The accuracy in differentiating AR and normal groups and also CR and normal groups, while the lowest sensitivity noticed in differentiating between AR and CR groups that is mean elasticity was good to differentiating between AR and normal groups and also between CR and normal groups while it was less in differentiating between AR and CR groups. **Conclusion:** Gray scale sonography and color Doppler are non-invasive, simple and cost effective screening modalities for renal transplant evaluation. Our study suggests usefulness of gray scale ultrasound and Doppler sonography in detection of vascular and urological causes of graft dysfunction. However it is of limited value in assessing parenchymal complications causing graft dysfunction.

Keywords: Renal Transplantation, Kidney Disease, Imaging Test.

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INTRODUCTION

Renal transplantation is the treatment of choice for managing patients with end-stage kidney disease. Being submitted to a very serious surgical procedure,

renal transplant recipients can only benefit from follow-up imaging and monitoring strategies. Ultrasound is considered as the principal imaging test in the evaluation of renal transplants. Renal transplantation is

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considered a treatment of choice for end-stage kidney disease (ESKD) since the 1960s. It is cost-effective and provides better long-term survival and better life quality in comparison to hemodialysis and/or peritoneal dialysis [1]. However, the risk of acute postoperative renal allograft rejection is high, with 40–80% of patients manifesting oliguria, hyperthermia, water and sodium retention, hypertension, and transplant renal enlargement/hardening/tenderness, ultimately resulting in kidney graft loss [2]. Imaging modalities to work up graft dysfunction include ultrasonography (US), computed tomography (CT), nuclear medicine (NM) or molecular imaging, and magnetic resonance imaging (MRI). The prognosis may be drastically improved in more than 90% of patients if the acute rejection is identified and treated at its early stage, but assessment methods are not optimal [3]. The use of appropriate diagnostic method in preoperative analysis but also in postoperative follow up protocol is necessary for accurate preparation and early diagnosis of complications and workflow efficiency [4]. The most important role of diagnostic radiological methods is to identify multiple complications in the post-transplant period [5]. Renal transplantation may be followed by many complications. The most frequent complications include perinephric fluid or collections (i.e., hematomas, seromas, urinomas, lymphoceles, and abscesses), decrease renal function (i.e., acute tubular necrosis, rejection and drug nephrotoxicity), abnormalities of the vascular structures (i.e., renal artery and vein stenosis or thrombosis, arteriovenous fistula), urinary tract obstruction, and renal parenchymal disease (i.e., pyelonephritis, infarction, or rejection) [6]. B-mode ultrasound is generally used for measuring transplant renal shape, size, hydronephrosis, and perinephric effusion, while color Doppler ultrasound is used to assess transplant renal perfusion. Both methods provide important imaging evidence for identification of renal graft rejection [7]. Color duplex sonography is the easiest, rapid, and noninvasive investigation to evaluate vascular complications and perfusion of the transplanted kidney. It is an excellent method for screening patients suspected to have renal artery stenosis [8, 9]. The goal of ultrasonographic (USG) and colour Doppler evaluation of the failing renal graft is to identify a treatable complication, to decide requirement of immediate intervention and to decide if a renal biopsy is required for diagnosis.

MATERIALS AND METHODS

The Duplex study was conducted at Dept. of Radiology and Imaging, CKD & Urology Hospital, Dhaka, Bangladesh from January to April 2022. Fifty patients (36 males and 14 females) who underwent renal transplantation were included. Their ages ranging from 16-60 years; they all subjected to ultrasound, color Doppler and histopathology. All patients underwent clinical evaluation as well as biochemical and radiological examination in the post-transplant period. They were evaluated on gray scale and color doppler as

a protocol on the 5th, 14th and 30th post-operative day. They were also evaluated as and when clinical suspicion of graft dysfunction was raised.

The patients were scanned on Samsung Medison R7 Ultrasound Machine. Scans were done with the patient in supine position. The transplant kidney, the region around the transplant as well as the bladder were included in the study. The following gray scale parameters were assessed: renal size and parenchyma, cortical echogenicity, cortico-medullary differentiation, size and appearance of medullary pyramids, pelvicalyceal system and presence of any collection. On color Doppler the main renal artery and the anastomosis were examined. The distribution of arterial flow throughout the transplant and also flow within the renal vein were assessed. The following indices of the arterial flow were measured: Resistive Index (RI), Pulsatility Index (PI), Peak systolic velocity (PSV), Acceleration time (AT), Acceleration Index (AI). After exclusion of vascular and urological causes of graft dysfunction, all the patients with deteriorating function were subjected to biopsy and the histopathological characteristics were correlated with USG and Doppler characteristics.

INCLUSION CRITERIA

1. The patient underwent renal transplantation who presented with clinical complication, proteinuria, or elevated serum creatinine.
2. Patient agrees to participate in the study for healthy subjects included age ≥ 10 years.
3. Patient body mass index less than 35 kg/m².

EXCLUSION CRITERIA

1. Body mass index greater than 35 kg/m²
2. Pregnancy or nursing status
3. Any conditions that impeded the visualization of the kidney by ultrasound
4. Patients who refuse to join this study.

RESULTS

A total of 50 renal transplant recipients were included in this study. Most number of patients, 12 (40%) were in the 30-39 years age group. There were 36 male and 14 female patients. 50 patients (100%) presented with a rise in serum creatinine. 4 patients (8%) presented with tenderness and swelling over transplanted kidney. 7 patients (14%) presented as uncontrolled hypertension. There were seven patients who developed chronic rejection (14%). Transplant renal artery stenosis was detected in 2 cases (4%). One case each of renal artery thrombosis (2%) were encountered. Peritransplant fluid collections were seen in 20 patients (40%). 2 patients (4%) developed post biopsy arterio-venous fistulas. Acute rejection was seen in 1 cases (2%) and Chronic rejection 4(8%) and Normal 45(90%). Five cases of cyclosporine toxicity (10%) and one case of ATN (2%) were encountered. The accuracy in differentiating AR and normal groups

and also CR and normal groups, while the lowest sensitivity noticed in differentiating between AR and CR groups that is mean elasticity was good to differentiating between AR and normal groups and also between CR and normal groups while it was less in differentiating between AR and CR groups.

Sonographic and Color Doppler Characteristics Of parenchymal complications:

Out of the 5(10%) patients of acute graft rejection 12 (70.58%) presented within a week of the transplantation, 3 (17.64%) within a month and 2 patient presented later (11.76%). The only case of ATN in our study presented on the 2nd day post transplantation. One case of cyclosporine toxicity presented within a month of surgery and the remaining two presented later. Out of the 5 patients of acute rejection, 12 patients (70.58%) revealed an increase in the size of the transplant kidney. Increased cortical echogenicity was observed in 8 patients (47.05%). Prominent medullary pyramids were noted in 5 patients (29.41%). Impaired cortico-medullary differentiation was seen in 4 patients (23.52%). 3 patients out of 5 with chronic graft rejection exhibited some increase in the cortical echogenicity with 2 patients showing prominent medullary pyramids. 1 patient had RI value between 7 and 8 with the remaining showing RI values <0.7. On color Doppler, increased impedance was seen in the form of raised RI values (>0.7) in 8 patients (80%) with

acute rejection. One patient with acute rejection had RI of more than 0.9. 2 patients had RI < 0.7. The patient with acute tubular necrosis had a RI of 0.88. 2 out of 3 patients with cyclosporine toxicity and 1 out of 4 patients with chronic rejection had RI of more than 0.7. On follow up scans after treatment, 3 patients of acute rejection showed normal morphological features on gray scale. The others showed persistence of sonographic features either in the form of allograft enlargement or increased cortical echogenicity. The RI and PI values returned to normal in all the cases. The sensitivity and specificity of Color Doppler flow imaging with a high threshold value of RI (>0.9) in diagnosis of Acute rejection was found to be 10% and 100% respectively.

Sonographic and Color Doppler Characteristics Of vascular complications:

Out of 7 patients who presented with hypertension and were clinically suspected to have transplant renal artery stenosis, 5 patients showed positive color doppler findings. No gray scale changes were noted in any of the cases. Table 1. On the basis of these findings a diagnosis of transplant renal artery stenosis was entertained in 5 patients. On angiography 4 out of 5 patients were confirmed to have significant renal artery stenosis. The sensitivity and specificity of color Doppler to detect transplant renal artery stenosis was found to be 100% and 96.1%.

Table-1: Color Doppler flow imaging characteristics in Transplant Renal Artery stenosis.

Doppler Fetures	No of Patients
Renal artery Peak systolic velocities >200cm/s	7
Focal turbulence/ aliasing	5
Renal + Intrarenal AT > 0.1 sec	5

One patient who presented within first post-transplant week with anuria was detected to have transplant renal artery thrombosis. Gray scale findings in this patient were normal. There was lack of arterial

flow in both the transplant artery and intrarenal vessels on both color flow and spectral Doppler analysis. (Fig-1). The diagnosis was confirmed by DSA. In spite of prompt intervention the graft could not be salvaged.

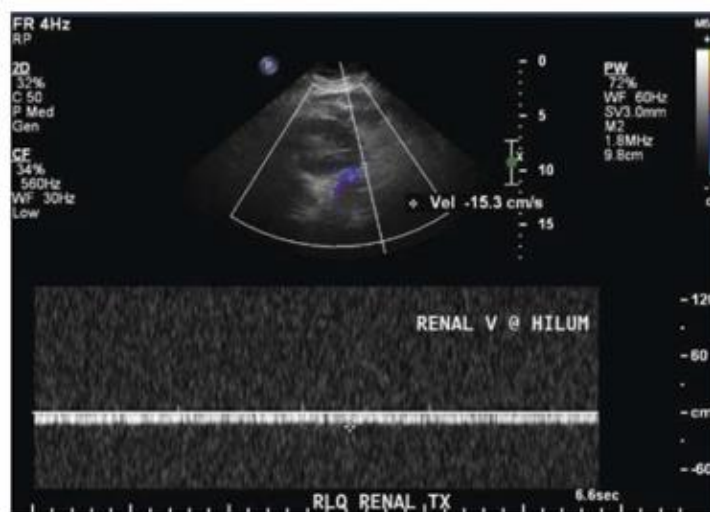


Fig-1: Renal arterial thrombosis-No flow is seen within the transplant kidney on color Doppler.

One patient who presented with tenderness and swelling over transplanted kidney on the 5 postoperative day was found to have enlarged, hypoechoic transplanted kidney on USG. On color Doppler flow imaging there was absence of venous flow with reversed diastolic flow within the intrarenal arterial system and transplanted renal artery. The diagnosis of renal vein thrombosis was considered which was confirmed on DSA. Graft nephrectomy had to be performed in this case.

Sonographic and Color Doppler Characteristics Of urological complications:

13 patients (43%) had peritransplant fluid collections. However only 5 patients had significant collections to result in graft dysfunction. Out of these 4 (31%) were lymphoceles (Fig-2). All the lymphoceles were located posteroinferomedial to the transplant. 2 patients (15%) had hematomas. Both of them were crescentic in shape and were located in the region around the kidney.

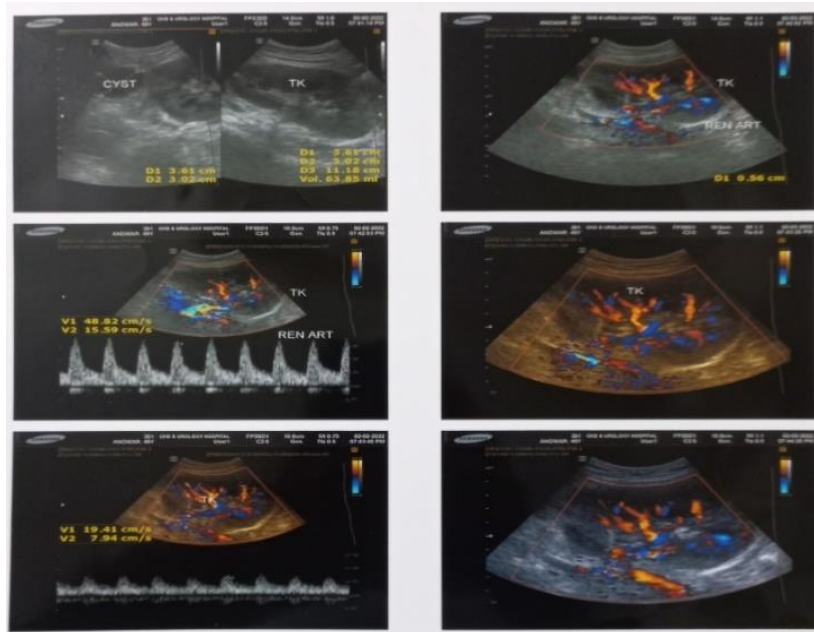


Fig-2: Lymphocele.

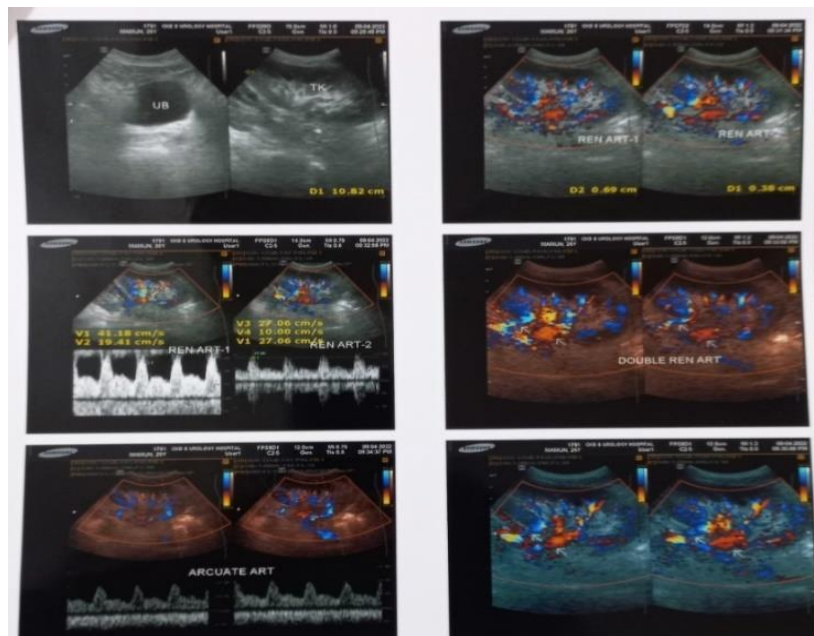


Fig-3: Accessory Renal arterial.

14 patients (28%) had small post op collections without any graft dysfunction. All of them showed regression on follow up scans. Their location

was variable and they appeared cystic in appearance. The sensitivity of ultrasound in detecting urological complications was found to be 100% (fig-3).

Table-2: Histopathological results of our patients (N=50)

	Number of cases (n %)
Histopathological results	
Normal	45(90%)
Acute Rejection	1(2%)
Chronic Rejection	4(8%)

Table 2 shows that histopathological results of Normal 45 (90%), Acute Rejection 1(2%) and Chronic Rejection 4 (8%). The statistical analysis as regards the difference between the mean elasticity values in differentiation between the three studied groups in our thesis was highly statistically significant (p value < 0.001), the specificity and accuracy the same between all groups studied with same sensitivity in differentiating group (AR and normal and CR and normal).

DISCUSSION

The most common gray scale change noted in our study was increase in the size of the transplant. The other findings were increase in cortical echogenicity, prominent medullary pyramids and impaired cortico-medullary differentiation. Allograft enlargement has been described as fairly specific for acute rejection [10]. Our study tried to assess the utility of resistive indices of blood flow measured by Doppler sonography to detect acute rejection. Using a high threshold RI i.e. > 0.9 the sensitivity and specificity of our study was 10% and 100% respectively. A total of 50 renal transplant recipients were included in this study. Most number of patients, 12 (40%) were in the 30-39 years age group. There were 36 male and 14 female patients. 50 patients (100%) presented with a rise in serum creatinine. 4 patients (8%) presented with tenderness and swelling over transplanted kidney. 7 patients (14%) presented as uncontrolled hypertension. There were seven patients who developed chronic rejection (14%). Transplant renal artery stenosis was detected in 2 cases (4%). This is in concordance with various reports published by other authors [11, 12]. There were two cases of acute rejection with RI < 0.7. Likewise, several studies have shown significant number of patients with acute rejection having normal RI values [13, 14]. Out of the 5 (10%) patients of acute graft rejection 12 (70.58%) presented within a week of the transplantation, 3 (17.64%) within a month and 2 patient presented later (11.76%). The only case of ATN in our study presented on the 2nd day post transplantation. One case of cyclosporine toxicity presented within a month of surgery and the remaining two presented later. Out of the 5 patients of acute rejection, 12 patients (70.58%) revealed an increase in the size of the transplant kidney. Increased cortical echogenicity was observed in 8 patients (47.05%). There was only one case of acute tubular necrosis in our study. There were no gray scale changes noted in this case. The RI and PI values were 0.88 and 1.9. Sonographic findings have been reported

to be normal in most cases of ATN [15]. However in cases of severe ATN the kidneys may be enlarged with poor cortico-medullary differentiation [16]. The RI and PI values were raised in our study. These values have not been found to be specific to differentiate between acute rejection and acute tubular necrosis [13, 14]. There were no changes either on gray scale or on color Doppler sonography in the case of cyclosporine toxicity encountered in our study. This is in consonance with previous studies where no significant sonographic changes were noted with cyclosporine toxicity [12]. One patient who presented within first post-transplant week with anuria was detected to have transplant renal artery thrombosis. Gray scale findings in this patient were normal. There was lack of arterial flow in both the transplant artery and intrarenal vessels on both color flow and spectral Doppler analysis. (Fig-1) The diagnosis was confirmed by DSA. In spite of prompt intervention the graft could not be salvaged. All the patients in this study had peak systolic velocities greater than 200cm/s. Focal turbulence and aliasing was commonly seen. The AT was increased in the post stenotic segment of the main renal artery. Our results approximates to that described by De Moraes *et al.* [17]. They documented a sensitivity and specificity of 90% and 87.5% for detection of renal artery stenosis when a cutoff value of Peak systolic velocities was taken as 200cm/sec. Our study had one false positive case. This can be explained by the fact that the tortuosity of the renal artery caused by an end-to-side anastomosis can cause high systolic velocities in the renal artery. There was one case of renal artery thrombosis in our study. Color Doppler flow imaging did not reveal any detectable flow within the main renal artery beyond the site of occlusion as well as in the intrarenal arteries. No venous flow was detected as well. Our study correlates well with the studies by Taylor *et al.* [18] who had detected 11 cases of Transplant Renal Artery thrombosis out of 88 renal transplant recipients. Only one case of renal vein thrombosis was detected in our study. The gray scale findings noted were enlargement of the graft with hypoechoic parenchyma. This is in concordance with the gray scale findings described by Rosenfield *et al.* [19]. On color Doppler imaging no flow was detected in the transplant vein and there was reversal of diastolic flow in the spectral traces of the main renal artery, segmental and interlobar arteries. Most were insignificant collections, which appeared immediately in postoperative period and did not cause any graft dysfunction. Most regressed spontaneously on follow up scans. This is in concordance with the findings of Silver *et al.* [20] who had described 28

small post-transplant collections in their study of 51 transplant recipients. 14 patients (28%) had small post op collections without any graft dysfunction. All of them showed regression on follow up scans in our study. Their location was variable and they appeared cystic in appearance. These were considered clinically insignificant and represent either seromas or hematomas. In our study histopathological results of Normal 45 (90%), Acute Rejection 1(2%) and Chronic Rejection 4 (8%). The statistical analysis as regards the difference between the mean elasticity values in differentiation between the three studied groups in our thesis was highly statistically significant (p value < 0.001), the specificity and accuracy the same between all groups studied with same sensitivity in differentiating group (AR and normal and CR and normal). The most common significant peritransplant collection in our study was lymphocele. This was similar to findings of Patricia Morley *et al*. [21]. The sensitivity of detection of significant fluid collections causing graft dysfunction by ultrasound was found to be 100%. This is in consonance with the findings of Silver *et al*. [20] who reported sensitivity of 100% in detection of peritransplant collections. Duplex Doppler interrogation of the feeding artery showed a high velocity, low resistance waveform and the draining vein had pulsatile arterialized flow. Our findings approximates that of Middleton *et al*. [22] who had observed arterialization of the venous waveform from the draining vein in all their 8 cases of arteriovenous fistulas.

CONCLUSION

Gray scale sonography and color Doppler are non-invasive, simple and cost effective screening modalities for renal transplant evaluation. Our study suggests usefulness of gray scale ultrasound and Doppler sonography in detection of vascular and urological causes of graft dysfunction. However it is of limited value in assessing parenchymal complications causing graft dysfunction.

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