

Can Color Doppler Resistive Index (RI) Assist Biopsy in Prediction of Post Renal Transplantation Rejection?

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Abstract

Background: The transplanted kidney is very precious and all efforts should be made to prolong its survival rate. However, graft rejection is one of the serious problems to long-term kidney transplant survival.

Aim of Study: The main aim of this study is to correlate between color Doppler findings and histopathological results of graft biopsy in post renal transplantation rejection patients.

Patients and Methods: This cross section study was performed on 35 renal transplant recipients, within two years of transplantation and was recruited after recent rise in renal function tests.

Results: The study was performed on 21 males (67.7%) and 10 females (32.3%). 8 patients had hypertension (25.8%) and 5 patients were diabetic (16%). The serum creatinine level of the patients ranged from 1.6 to 7.2mg/dl (mean 3.07 ± 1.21 mg/dl). The serum urea level ranged from 44 to 79mg/dl (mean 63.55 mg/dl). Use of immunosuppressive drugs: 12 patients used tacrolimus out of 31 (38.7%) while 19 patients out of 31 used cyclosporine (61.29%). Doppler findings: RI in the main renal artery ranged from 0.60 to 1 (mean 0.80 ± 0.8), RI in the interlobar artery ranged from 0.53 to 1 (mean 0.76 ± 0.1). The PI of main renal artery ranged from 1 to 2.49 (mean 1.76 ± 0.34). Classification was done according to Banff system corresponding to results of renal biopsy.

Conclusion: With agreements to many studies, this study supports the fact that ultrasound imaging is a key method of post-transplant monitoring in kidney transplantation patients with the benefits of gray scale ultrasound and Color Doppler as noninvasive, simple and cost effective screening modalities for renal transplant evaluation, adding to that early prediction of transplant rejection & its correlation with histopathological results.

Key Words: Color Doppler resistive index – Renal transplant – Graft rejection.

Introduction

THE kidney is an important filtrating organ of the body keeping the nutrients that the body needs in

and removing the waste. Many diseases can affect the renal functions such as hypertension, diabetes, glomerular disease and polycystic kidney disease [1]. These can deteriorate the renal function and end up with chronic kidney disease. When the kidney reaches stage 5 chronic kidney disease, the only definite therapy is renal transplantation [2]. Although it is the main therapy, lack of kidney donors is still difficult and challenging. Therefore, the transplanted kidney is very precious and all efforts should be made to prolong its survival rate. However, graft rejection is one of the serious problems to long-term kidney transplant survival. The early diagnosis of allograft rejection is crucial and enables rapid treatment [3]. Post transplantation routine assessment of kidney function is very important to prevent loss of the renal graft. The National Kidney Foundation (NKF) recommended measuring overall kidney function by glomerular filtration rate (GFR), which is based on measuring the serum creatinine level. However, this test is of low sensitivity and is a late marker for renal graft dysfunction (a significant change in serum creatinine level is detectable only after the loss of 60%

List of Abbreviations:

AAABMR : Acute Active Antibody Mediated Rejection.
AATCMR : Acute Active T Cell Mediated Rejection.
ABMR : Antibody Mediated Rejection.
ABMR : Antibody-Mediated Rejection.
ACABMR : Active Chronic Antibody Mediated Rejection
ACR : Acute Cellular Rejection.
ATN : Acute Tubular Necrosis.
BUN : Blood Urea Nitrogen.
CD : Color Doppler.
CDUS : Color Doppler Ultrasound.
CKD : Chronic Kidney Disease.
CTCMR : Chronic T Cell Mediated Rejection.
MMF : Mycophenolate Mofetil.
RI : Resistive Index.
ROIs : Region Of Interests.
TCMR : T Cell-Mediated Rejection.
US : Ultrasound.

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of renal function) [4]. Ultrasound (US) imaging is usually used for the early assessment of renal allografts function in the postoperative period as well as for the assessment in the long-term follow-up due to being a relatively easy to be performed and repeated, inexpensive, and non-nephrotoxic imaging modality [5]. Pulsatility index (PI) and resistance index (RI) are the most common measurements to assess renal function using US [2]. Ultrasonography can also be used to guide diagnostic and therapeutic interventions, such as biopsy, fluid aspiration, or drainage. It helps to detect parenchymal abnormalities, but its role in differentiating different parenchymal disease processes, such as graft rejection, acute tubular necrosis, or drug toxicity, is limited [6].

The main aim of this study is to correlate between color Doppler findings and histopathological results of graft biopsy in post renal transplantation rejection patients.

Patients and Methods

This cross section study was approved by the ethical committee of our institute. It was performed on 35 renal transplant recipients (24 males, 11 females) with age range from 25 to 57 years (mean age of 34.6 years), they were referred from nephrology department. The study was conducted between April 2017 to October 2018, in Cairo, Egypt.

Inclusion criteria:

The study included recipients of living donor renal transplants for the first time of age group above 16 years old whatever male or female, when there is evidence of deteriorating renal function on their follow-up.

Exclusion criteria:

We excluded patients below 16 years old or any pre renal or post renal causes of elevated serum creatinine.

Four patients were excluded after receiving treatment without need for biopsy. Two of them were severely dehydrated and creatinine dropped with intravenous fluid administration. Other two showed very high immunosuppressive drug levels and creatinine normalized with the drug dose adjustment.

The remaining 31 patients were scheduled for renal biopsy to reach diagnosis after exclusion of all pre-renal, post-renal and other correctable causes of renal graft dysfunction. All patients wrote a prior consent of inclusion in this study.

All transplant patients included in this study were seeking medical advice after rise in serum creatinine level and were subjected to Clinical assessment: Complete history taking with emphasizing on history of the postoperative course in details including present history, Date of the surgery, complications, medications and immunosuppressive drugs details, history of DM or hypertension and history of other medical conditions. Laboratory assessment: (Routine and general evaluation tests), Kidney function tests (Blood urea nitrogen, Serum creatinine and Urine analysis). Radiological assessment: Ultrasound examination of the transplanted kidney including Doppler examination was performed. Examinations performed with a 3.5 MHz real-time sector scanner. The entire renal transplant was scanned on both long and short axes. Careful attention was done to renal morphology to identify the features of rejection/ other pathologies. The Doppler signal was sampled from two sites: The main renal artery at the hilum and the interlobar arteries. The angle between the ultrasound beam and the vessel under study was altered to achieve the maximal Doppler shift frequency for each vessel. Estimation of RI values in the main transplant artery and interlobar artery, PSV in both main transplant artery and external iliac artery with estimation of PI in the main transplant artery. Images of the real-time and of the Doppler frequency spectrum were recorded. Results were compared with clinical and biochemical status, histopathology when available.

Statistical analysis:

Data were coded and entered using the statistical package SPSS version 25. Data was summarized using mean, standard deviation, median, minimum and maximum in quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparisons between groups were done using unpaired *t*-test when comparing 2 groups and analysis of variance (ANOVA) with multiple comparisons post hoc test when comparing more than 2 groups (Chan, 2003a). For comparing categorical data, Chi square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5 (Chan, 2003b). Correlations between quantitative variables were done using Spearman correlation coefficient (Chan, 2003c). *p*-values less than 0.05 were considered as statistically significant.

Results

The study included 21 males (67.7%) and 10 females (32.3%). 8 patients had hypertension (25.8%). 5 patients were diabetic (16%). The serum

creatinine level of the patients ranged from 1.6 to 7.2mg/dl (mean 3.07 ± 1.21 mg/dl). The serum urea level of the patients ranged from 44 to 79mg/dl (mean 63.55mg/dl). Tacrolimus: 12 patients out of 31 used tacrolimus (38.7%). Cyclosporine: 19 patients out of 31 used cyclosporine (61.29%). RI in the main renal artery ranged from 0.60 to 1 (mean 0.80 ± 0.8). RI in the interlobar artery ranged from 0.53 to 1 (mean 0.76 ± 0.1). The PI of main renal artery ranged from 1 to 2.49 (mean 1.76 ± 0.34). According to the results of the renal biopsy, classification was done according to Banff system. Rejection: 16 patients out of 31 patients had rejection (51.6%). Patients with acute tubular necrosis (ATN): 6 out of 31 patients had ATN (19.4%). Patients with drug toxicity (CNI toxicity): 3 out of 31 patients had CNI toxicity (9.7%). Rejection was further classified into five categories according

to the pathology. (A) Patients with acute active antibody mediated rejection (acute AB rejection): 2 out of 31 patients (6.5%) representing 12.5% of the total rejection cases. (B) Patients with active chronic antibody mediated rejection: 2 out of 31 patients (6.5%) representing 12.5% of the total rejection cases. (C) Patients with acute active T cell mediated rejection: 6 out of 31 patients (19.4%) representing 37.5% of the total rejection cases. (D) Patients with acute on top of chronic T cell rejection: 4 out of 31 patients (12.9%) representing 25% of the total rejection cases. (E) Patients with mixed or combined type of rejection (includes antibody mediated rejection ad T cell mediated rejection): 2 out of 31 patients (6.5%) representing 12.5% of the total rejection cases. Mean RI of the rejection cases in relation to type of rejection (Table 1).

Table (1): Mean RI of the rejection cases in relation to type of rejection.

	AAABMR	ACABMR	AATCMR	Acute on top of CTCMR	Mixed type of rejection
Main RA RI	0.78±0.01	0.86±0.05	0.78±0.03	0.82±0.06	0.82±0.05
p-value	0.676	0.289	0.535	0.736	0.719
ILA RI	0.79±0.11	0.84±0.08	0.76±0.04	0.79±0.05	0.76±0.01
p-value	0.681	0.336	0.902	0.615	0.893

RA : Renal artery. AAABMR : Acute active antibody mediated rejection. AATCMR : Active acute T cell mediated rejection.
 ILA: Interlobar artery. ACABMR : Active chronic antibody mediated rejection. CTCMR : Chronic T cell mediated rejection.

Resistivity indices measured into main renal artery and interlobar artery. Types of rejection classified into:

AAABMR: Active acute antibody mediated rejection, ACABMR: Active chronic antibody mediated rejection, AATCMR: Active acute T cell mediated rejection, CTCMR: Chronic T cell mediated rejection. The mean Doppler indices measured from the intrarenal vessels in AAABMR cases were a main renal artery resistivity index (RI) of 0.78 ± 0.01 , interlobar resistive index of 0.79 ± 0.11 and a pulsatility index (PI) of 1.48 ± 0.04 . The mean peak systolic velocities (PSV) measured from the main renal arteries 122.5 ± 17.68 cm/s. (Fig. 1A,B).

The mean Doppler indices measured from the intrarenal vessels in ACABMR cases were a main renal artery resistivity index (RI) of 0.86 ± 0.05 , interlobar resistive index of 0.84 ± 0.08 and a pulsatility index (PI) of 2.48 ± 0.02 . The mean peak systolic velocities (PSV) measured from the main renal arteries 221.5 ± 60.10 cm/s. The mean Doppler

indices measured from the intrarenal vessels in AATCMR cases were a main renal artery resistivity index (RI) of 0.78 ± 0.03 , interlobar resistive index of 0.76 ± 0.04 and a pulsatility index (PI) of 1.66 ± 0.22 . The mean peak systolic velocities (PSV) measured from the main renal arteries 131 ± 29.86 cm/s. The mean Doppler indices measured from the intrarenal vessels in acute on top of CTCMR cases were a main renal artery resistivity index (RI) of 0.82 ± 0.06 , interlobar resistive index of 0.79 ± 0.05 and a pulsatility index (PI) of 1.80 ± 0.15 . The mean peak systolic velocities (PSV) measured from the main renal arteries 102.45 ± 31.94 cm/s. The mean Doppler indices measured from the intrarenal vessels in mixed type rejection cases were a main renal artery resistivity index (RI) of 0.82 ± 0.05 , interlobar resistive index of 0.76 ± 0.01 and a pulsatility index (PI) of 1.84 ± 0.22 . The mean peak systolic velocities (PSV) measured from the main renal arteries 164.5 ± 13.44 cm/s. The mean RI in rejection versus non-rejection cases demonstrated in (Table 2).

Table (2): Mean RI in rejection versus non-rejection cases.

	Rejection		<i>p</i> -value
	Yes	No	
Main RA (Doppler)	0.81±0.05	0.80±0.3	0.927
Interlobar A (Doppler)	0.78±0.05	0.75±0.1	0.732

The mean Doppler indices measured from the intrarenal vessels in rejection cases as a whole were a main renal artery resistivity index (RI) of 0.81±0.05, interlobar resistive index of 0.78±0.05 and a pulsatility index (PI) of 1.80±0.33. The mean peak systolic velocities (PSV) measured from the main renal arteries 138.30±46.76cm/s. This group of pathology shows no significant difference in the RI measurements either in the main renal artery or the interlobar artery to differentiate between different types of rejection.

A- Patients with acute tubular necrosis (ATN): 6 out of 31 patients (19.4%) had ATN (Fig. 2A,B).

The mean RI values in both main renal artery and interlobar artery are of higher values in ATN cases than in non-ATN cases. The mean Doppler indices measured from the intrarenal vessels in ATN cases were a main renal artery resistivity index (RI) of 0.87±0.07, interlobar resistive index of 0.84±1.0, and a pulsatility index (PI) of 1.99±0.22. The mean peak systolic velocities (PSV) measured from the main renal arteries 162.83±56.71cm/s. This group of pathology shows significant difference in the RI measurements in both main renal artery and interlobar artery in differentiation between ATN and non-ATN cases, with *p*-value = 0.037 & 0.039 in the main renal artery and interlobar artery respectively (Table 3).

Table (3): Mean RI in ATN versus non-ATN cases.

	ATN		<i>p</i> -value
	Yes	No	
Main RA (Doppler)	0.87±0.7	0.79±0.08	0.037
Interlobar A (Doppler)	0.84±0.1	0.75±0.1	0.039

B- Patients with drug toxicity (CNI toxicity): 3 out of 31 patients (9.7%) had CNI toxicity (Table 4). The mean Doppler indices measured from the intrarenal vessels in toxicity cases were a main renal artery resistivity index (RI) of 0.81±0.2,

interlobar resistive index of 0.78±0.2 and a pulsatility index (PI) of 1.63±0.55. The mean peak systolic velocities (PSV) measured from the main renal arteries 139.67±58.32cm/s. This group of pathology shows no significant difference between RI measurements to differentiate between toxicity cases and non-toxicity cases.

Table (4): Mean RI in drug toxicity versus non-drug toxicity cases.

	Drug toxicity		<i>p</i> -value
	Yes	No	
Main RA (Doppler)	0.81±0.2	0.80±0.07	0.939
Interlobar A (Doppler)	0.78±0.2	0.75±0.1	0.841

C- Other pathologies: 6 out of 31 patients (19.4%) were inadequate and normal pathology samples. Correlation between serum creatinine level (in mg/dl) and different Doppler parameters (Table 5), using Spearman coefficient we concluded that there is a correlation between different Doppler parameters measurements and the level of serum creatinine in mg/dl. There is a statistically significant correlation between serum creatinine level and RI measurements in the main renal artery and interlobar artery with *p*-value 0.03 and 0.04 respectively.

Table (5): Summarizes the correlation between serum creatinine and RI measures.

	Serum creatinine		<i>p</i> -value
	Correlation coefficient		
RI MRA	0.511		0.03
RI ILA	0.501		0.04

Relation between RI measures and type of medications used (Table 6); Patients were classified according to the immunosuppressive drugs they used into two groups: Cyclosporine (61.29%) and Tacrolimus (38.7%). There was no correlation between RI measurements and the tacrolimus and cyclosporine group.

Table (6): Summarizes the relation between Doppler indices and use of medication.

	Cyclosporine	Tacrolimus	<i>p</i> -value
MRA RI	0.81±0.1	0.80±0.05	0.694
ILA RI	0.76±0.11	0.77±0.09	0.726
MRA PI	1.8±0.39	1.69±0.21	0.339

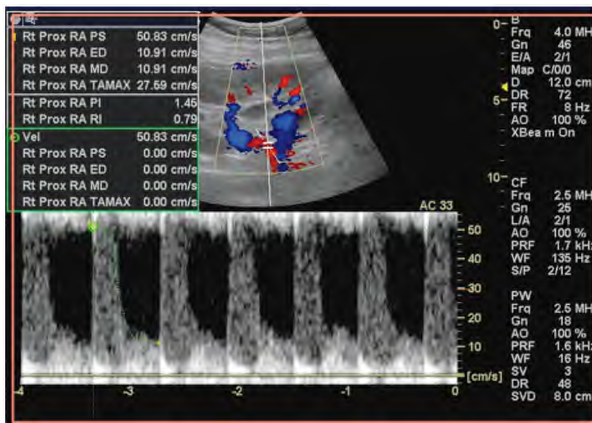


Fig. (1A): Female patient, 26 years old underwent renal transplantation 2 weeks earlier. Presented with oliguria and raised creatinine (3mg/dl). Grey Scale US showed normal appearance of renal graft. Doppler indices showed elevated both PI and RI (1.45 and 0.79 respectively) of main renal artery. Normal vascularization of the graft with no evidence of arterio-venous communication. RI value at main transplant artery is 0.79. PI at renal transplant artery is 1.45. RI value at interlobar artery is 0.87. PSV at renal artery: 110cm/sec. Patent renal artery and renal vein. The external iliac artery is patent with normal renal/external iliac artery PSV ratio (no evidence of renal artery stenosis). The external iliac vein is patent with normal Doppler flow. The renal vein is patent and shows normal Doppler flow.

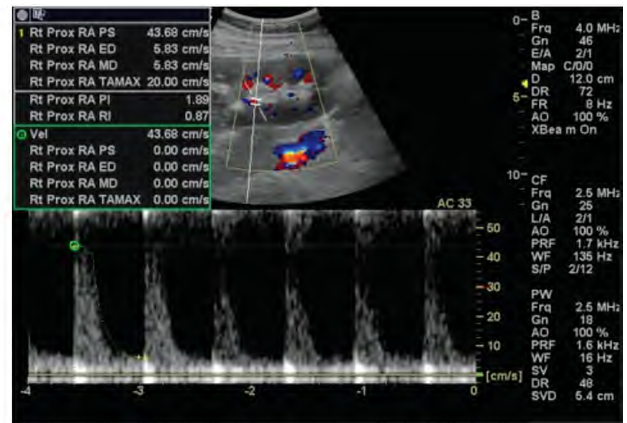


Fig. (1B): Elevated RI (0.87) of interlobar artery is also noted in the same patient as a Doppler finding. Histopathological results showed acute active antibody mediated rejection with borderline category according to Banff classification system (picture consistent with inadequate immunosuppression or non compliance). Treatment was Plasma pheresis.

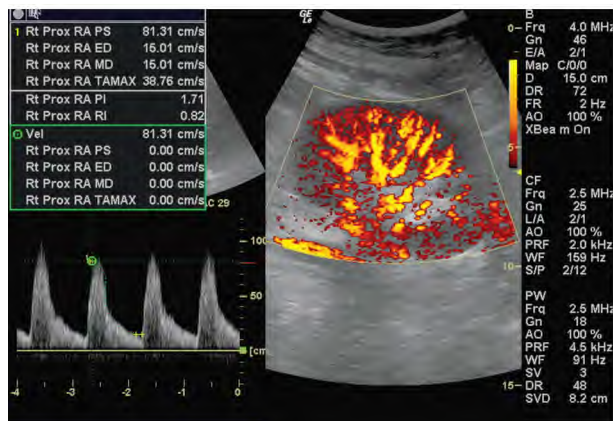


Fig. (2A): Doppler study of main renal artery of the transplanted kidney in 33 years-old female patient with history of SLE presented on the 4th day post transplantation with oliguria and blood pressure 90/50mmHg. RI of the main renal artery (0.82). PI of the main renal artery (1.71). The graft appears well vascularized with no evidence of arteriovenous communication. RI value at main transplant artery is 0.82. PI at transplant main artery is 1.71. RI value at interlobar artery is 0.82. Patent renal artery and vein. PSV at transplant renal artery is 145cm/sec and at external iliac artery is 109 cm/sec. The external iliac artery is patent with normal renal/external iliac artery PSV ratio (no evidence of renal artery stenosis). The external iliac vein is patent with normal Doppler Flow. The renal vein of transplanted kidney is patent shows normal Doppler flow.

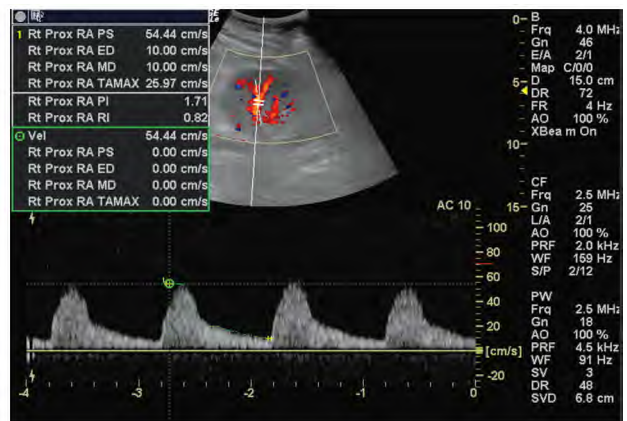


Fig. (2B): RI at interlobar artery (0.82) of the same patient as Doppler finding. Histopathological results showed moderate tubular injury with mild interstitial edema, picture consistent with ischemic acute tubular necrosis (ATN). The case treated by hydration using fluids and trial of IV steroids.

Discussion

Renal transplantation remains the treatment of choice for chronic kidney disease (CKD) patients [7]. Although improvements in surgical techniques and immunosuppression have led to longer survival, complications remain common, occurring in approximately 12%-20% of patients [8]. Post transplantation complications can also be divided following the renal transplant's time of evolution into early complications (Acute Tubular Necrosis, Acute

Rejection, arterial or venous thrombosis, obstruction, urinary leak, post transplantation collections and infection) and late complications (Transplant Artery Stenosis, Arteriovenous fistulas, drugs toxicity, chronic rejection and urinary tract infection). Imaging techniques plays an important role in the detection of anatomical as well as functional abnormalities in all post transplant stages, thus allowing the chance for early treatment [9]. Gray scale ultrasound and spectral Doppler US do not exhibit high specificity and sensitivity because

different renal parenchymal diseases often display the same US appearance, whereas the same renal parenchymal disease may present different appearances on US according to disease stage. Consequently, correlation of the US pattern with patient's history and clinical background is essential for a correct characterization. However, there are several limitations to US including its inability to assess renal function or differentiate between the different causes of renal dysfunction. For appropriate evaluation of a graft dysfunction, renal biopsy remains the gold standard for diagnosis [10]. Our results showed that: Group I: Recipients with rejection representing 16 out of 31 patients (51.6%). This finding has similarity to the results of Zheng et al., [11] as 50% of the cases in their study had rejection. Group II: Recipients with ATN representing 6 out of 31 patients (19.4%). This finding has similarity to the results of Patel et al., [12], who conducted a study on 46 patients and 19% of them had ATN. Also Fananapazir & Troppmann, [13] stated that the overall acute tubular necrosis occurs in 10-30% of transplant recipients and is usually an early sign of renal graft dysfunction. Group III: Recipients with CNI toxicity representing 3 out of 31 patients (9.7%). This finding is similar to the results of Mathur & Gopinath, [14], who conducted a study on 30 renal transplant patients and 3 of them had CNI toxicity. Group IV: Recipients with other pathologies (normal or inadequate biopsy) representing 6 out of 31 patients (19.4%). Recipients in Group I was sub-divided into: (A) Patients with acute active antibody mediated rejection. (B) Patients with active chronic antibody mediated rejection. (C) Patients with acute active T cell mediated rejection. (D) Patients with acute on top of chronic T cell mediated rejection. (E) Patients with mixed type of rejection (antibody and T cell mediated rejection). We found that 38.7% of our patients have acute rejection, this is in agreement with Garcia-Villar et al., 2017's work [9] who found that acute rejection is the most common type of allograft rejection, affecting up to 40% of patients with renal transplants. We found that the cellular type of rejection is the predominant type either acute type (n=6) or acute on top of chronic (n=4) or mixed type (n=2). Similar to Contti et al., [15] who found that all rejection episodes in their study were mediated by T cells (Banff IA and IB), also Hass, [16] reported that acute cellular rejection is the most common type while acute antibody-mediated rejection is less common. In contrast to Kunchala et al., [17], their study was carried on 12 Indian patients with 15 biopsies, 13 of them were ABMR either isolated or combined with cellular type. They explained that most of the patients were

noncompliant to immunosuppressive therapy and they considered it as the main cause of ABMR. Similar to Zheng et al., [11], we also found, that T cell mediated rejection can perpetuate as chronic type or combined with antibody mediated. McBryde & Kaiser, [18] reported that it is possible to find both ACR and acute ABMR on biopsy during these episodes of early acute rejection. In our study we found that the most frequent rejection category in the pathology reports is the borderline category (cellular rejection), which presents 41.6% of the Banff classifications reports. In contrast to Patel et al., [12] who studied 47 patients in the early post transplantation period (one month), they found 18 out of 47 patients were grade II rejection, this can be attributed to the large number of rejection cases (61%) and the timing of their study in the early post-operative period. Inci et al., [19] & Contti et al., [15] also stated that the role of Doppler US in differentiating different parenchymal disease processes, such as graft rejection, acute tubular necrosis, or drug toxicity, is limited and no parameter was able to distinguish rejection and no association between US parameters, either alone or combined, with rejection was found. In this study, we could not find a cut off value of the resistive index to differentiate between the rejection cases from other pathologies, this finding agrees with Shebl et al., [20] who concluded that on resistive index measurements basis, color Doppler sonography had a limited value in the differentiation among the various etiologies of renal transplant dysfunction. They found that the mean RI values were above normal in acute rejection and ATN, with no cut-off value between the two entities. Meire et al., [21] also found that single measurements of the RI have low diagnostic accuracy for acute complications and chronic dysfunction after kidney transplantation and concluded that successive monitoring of the RI and serial duplex index can improve accuracy. In our study we found that there is a significant difference in the RI measurements between ATN cases and non-ATN cases with mean RI in the main renal artery 0.87 ± 0.07 and interlobar resistive index of 0.84 ± 1.0 and significant P value of both = 0.037 and 0.039 respectively. This finding is similar to the study of Contti et al., [15], who found that high RI was associated with ATN with quantified RI and power Doppler cutoff point was set at 0.84, with 81.6% sensitivity and 70.7% specificity with agreements to Araújo & Suassuna, [22], who confirmed that RI has a linear and significant association with recipient age and tubular necrosis. In our study we found that there is a statistically significant non linear correlation between serum creatinine and RI measurements in

the main renal artery and interlobar artery with p -value 0.03 and 0.04 respectively and that is in agreement with Melek et al., [23] who found that the mean serum creatinine and BUN values of patients with RI values ≥ 0.7 were significantly higher than that of patients with RI values < 0.7 . This study certainly revealed that there is a significant difference in RI values of the interlobar artery in detection of rejection, ATN and drug toxicity compared to other pathologies (normal or inadequate biopsies) with p -value=0.002. The above results could somehow lead physicians to emphasis on the role of interlobar artery with an elevated RI value in the detection of different parenchymal complications especially the early complications, considering it more specific than the main renal artery and that came with agreement with Venkatesh et al., [24], who found an association between RI and transplant graft dysfunction in the early transplant period.

Conclusion:

With agreements to many studies, this study supports the fact that ultrasound imaging is a key method of post-transplant monitoring in kidney transplantation patients with the benefits of gray scale ultrasound and Color Doppler as noninvasive, simple and cost effective screening modalities for renal transplant evaluation. However it is of limited value in assessing the etiology of graft dysfunction. Despite its poor specificity, arterial RI is the only quantitative parameter that is widely used to reflect renal parenchymal status. So, we do recommend serial measurements of RI especially in the early period after kidney transplantation as valuable marker to determine graft function and whether acute tubular necrosis is suspected or not.

References

- 1- KUKLA A., ADULLA M., PASCUAL J., SAMANIEGO M., et al.: CKD stage-to-stage progression in native and transplant kidney disease. *Nephrol. Dial Transplant*, 23 (2): 693-700, 2008.
- 2- HOLLIS E., SHEHATA M., KHALIFA F., ABOU EL-GHAR M., et al.: Towards non-invasive diagnostic techniques for early detection of acute renal transplant rejection: A review. *Egyptian Journal of Radiology and Nuclear Medicine*, 48 (1): pp. 257-269, 2017.
- 3- CHOW L., SOMMER F.G., HUANG J. and LI K.C.: Power Doppler imaging and resistance index measurement in the evaluation of acute renal transplant rejection. *J. Clin. Ultrasound*, 29: 483-490, 2001.
- 4- MYERS G.L., MILLER M.G., CORESH J., FLEMING J., et al.: Recommendations for improving serum creatinine measurement: A report from the laboratory working group of the national kidney disease education program. *Clin. Chem.*, 52, p. 1: 5-18, 2006.
- 5- MOSTAPHA M., KHALIFA F., ALANSARY A., SOLIMAN A., et al.: Computer aided diagnosis systems for acute renal transplant rejection: Challenges and methodologies. In: El-Baz S.A., Saba L., Suri J., editors. *Abdomen and thoracic imaging: An engineering & clinical perspective*. Boston (MA, US): Springer, p. 1-35, 2014.
- 6- BROWN E.D., CHEN M.Y., WOLFMAN N.T., OTT D.J., et al.: Complications of renal transplantation: Evaluation with US and radionuclide imaging. *Radiographics*, 20 (3): 607-22, 2000.
- 7- HUESO M., NAVARRO E., SANDOVAL D. and CRUZADO J.M.: Progress in the development and challenges for the use of artificial kidneys and wearable dialysis devices. *Kidney Diseases*, 1-8, 2018.
- 8- KIM N., JUAREZ R. and LEVY A.D.: Imaging non-vascular complications of renal transplantation. *Abdominal Radiology*, 17: 1-9, 2018.
- 9- GARCIA-VILLAR C.: Complications of renal transplantation: Diagnosis and treatment. *European Congress of Radiology*, 2017.
- 10- GALGANO S.J., LOCKHART M.E., FANANAPAZIR G. and SANYAL R.: Optimizing renal transplant Doppler ultrasound. *Abdominal Radiology*, 43 (10): 2564-73, 2018.
- 11- ZHENG L., WANG J., GAO W., HU C., WANG S., et al.: GC/MS-based urine metabolomics analysis of renal allograft recipients with acute rejection. *Journal of Translational Medicine*, 16 (1): 202, 2018.
- 12- PATEL K.N., PATEL N.A. and GANDHI S.P.: Comparison between doppler ultrasound resistive index, serum creatinine, and histopathologic changes in patients with kidney transplant dysfunction in early posttransplantation period: A single center study with review of literature. *Saudi Journal of Kidney Diseases and Transplantation*, 27 (3): 533, 2016.
- 13- FANANAPAZIR G. and TROPFMANN C.: Kidney Transplantation. In *Transplantation Imaging*. Springer, Cham., pp. 81-104, 2018.
- 14- MATHUR A. and GOPINATH M.: Ultrasound and color Doppler evaluation of renal transplant dysfunction. *International Journal of Scientific Research*, 7 (4), 2018.
- 15- CONTTI M.M., GARCIA P.D., KOJIMA C.A., NGA H.S., et al.: Quantified power Doppler as a predictor of delayed graft function after renal transplantation. *International Urology and Nephrology*, 47 (2): 405-12, 2015.
- 16- HAAS M.: The revised (2013) Banff classification for antibody mediated rejection of renal allografts: Update, difficulties, and future considerations. *American Journal of Transplantation*, 16 (5): 1352-7, 2016.
- 17- KUNCHALA R., GUDIPATI A., GUDITI S., TADURI G., et al.: Late acute rejection in renal allografts: Clinical, pathologic, and follow-up data from a single tertiary care center. *Indian Journal of Transplantation*, 12 (1): 48, 2018.
- 18- MCBRYDE K.D. and KAISER B.A.: Causes of Early Kidney Allograft Non-function. *Solid Organ Transplantation in Infants and Children*, 1-0, 2017.
- 19- INCI M.F., OZKAN F., SEE T.C. and TATLI S.: Renal transplant complications: Diagnostic and therapeutic role of radiology. *Canadian Association of Radiologists Journal*, 65 (3): 242-52, 2014.

- 20- SHEBEL H.M., AKL A., DAWOOD A., EL-DIASTY T.A., et al.: Power Doppler sonography in early renal transplantation: does it differentiate acute graft rejection from acute tubular necrosis? Saudi J. Kidney Dis. Transpl., 25 (4): 733-40, 2014.
- 21- MEIER M., FRICKE L., EIKENBUSCH K., SMITH E., et al.: The serial duplex index improves differential diagnosis of acute renal transplant dysfunction. Journal of Ultrasound in Medicine, 36 (8): 1607-15, 2017.
- 22- ARAÚJO N.C. and SUASSUNA J.H.: Determinant Variables of Resistive Index in Early Renal Transplant Recipients. In Transplantation proceedings. Elsevier, Jul 1, Vol. 48, No. 6, pp. 1955-1961, 2016.
- 23- MELEK E., BASKIN E., GULLEROGLU K., USLU N., et al.: The predictive value of resistive index obtained by Doppler ultrasonography early after renal transplantation on long term allograft function. Pediatric Transplantation, 21 (2): e12860, 2017.
- 24- VENKATESH L. and HANUMEGOWDA R.K.: Is there an association between renal resistance index and early postrenal transplant function? Survival, 5: 7, 2018.

هل نتائج لون دوبلر تساعد نتائج تحليل الأنسجة في الإكتشاف المبكر للرفض بعد زرع الكلى؟

الكلى هي عضو مهم في ترشيح الجسم للحفاظ على العناصر الغذائية التي يحتاجها الجسم وإزالة الفضلات. يمكن أن تؤثر العديد من الأمراض على وظائف الكلى مثل ارتفاع ضغط الدم والسكري وأمراض الكبيبات ومرض الكلى المتعدد الكيسات. يمكن أن يؤدي ذلك إلى تدهور وظائف الكلى وينتهي بها الأمر إلى الإصابة بأمراض الكلى المزمنة. عندما تصل الكلى إلى المرحلة الخامسة من مرض الكلى المزمن، فإن العلاج الوحيد المحدد هو زرع الكلى. على الرغم من أنها العلاج الرئيسي، إلا أن نقص المتبرعين بالكلى لا يزال صعباً. لذلك، فإن الكلى المزروعة ثمنية للغاية ويجب بذل كل الجهود لإطالة معدل بقائها على قيد الحياة. ومع ذلك، فإن رفض الكل وأحد المشاكل الخطيرة التي تحول دون بقاء زراعة الكلى على المدى الطويل. يعد التشخيص المبكر لرفض الزرع أمراً بالغ الأهمية ويسمح بالعلاج السريع. يعد التقييم الروتيني لوظيفة الكلى بعد الزرع مهماً جداً لمنع فقدان الزرع الكلوي أو صحت مؤسسة الكلى الوطنية (NKF) بقياس وظائف الكلى الكلية عن طريق معدل الترشيح الكبيبي (GFR)، والذي يعتمد على قياس مستوى الكرياتينين في الدم. ومع ذلك، فإن هذا الاختبار ذو حساسية منخفضة وهو علامة متأخرة لاختلال وظيفة الزرع الكلوي (لا يمكن اكتشاف تغيير كبير في مستوى الكرياتينين في الدم إلا بعد فقدان ٦٠٪ من وظائف الكلى). عادة ما يتم استخدام التصوير بالموجات فوق الصوتية (الولايات المتحدة) للتقييم المبكر لوظيفة الطعوم الكلوية في فترة ما بعد الجراحة وكذلك للتقييم في المتابعة طويلة الأجل نظراً لكونها سهلة نسبياً في التنفيذ ومتكررة وغير مكلفة وغير مكلفة. طريقة التصوير السمية الكلوية. يعتبر مؤشر النبض (PI) ومؤشر المقاومة (RI) أكثر القياسات شيوعاً لتقييم وظائف الكلى باستخدام US. يمكن أيضاً استخدام التصوير بالموجات فوق الصوتية لتوجيه التدخلات التشخيصية والعلاجية، مثل الخزعة أو شفت السوائل أو التصريف، فهو يساعد على اكتشاف تشوهات ننتي، ولكن دوره في التفريق بين عمليات مرض متنى مختلفة، مثل رفض الكلى، أو تنخر أنبوبي حاد، أو دواء سمية محدودة.

الهدف الرئيسي من هذه الدراسة هو الربط بين نتائج لون دوبلر ونتائج تحليل الأنسجة في مرضى الرفض بعد زرع الكلى.