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ROLE OF RENAL ULTRASONOGRAPHY AND DOPPLER IN DETECTION OF COMPLICATIONS OF POST-TRANSPLANTED KIDNEY

By

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ABSTRACT

Background: The increasing number of renal transplantations and the increased survival rate of renal transplantation patients lead to an increase of the number of complications. Complications of renal transplant can be diagnosed and managed with minimally invasive techniques. Radiologists must know about post-renal transplant complications, since it is essential to respond with early treatment, which improves the prognosis of the transplanted kidney. Most complications can be detected by Doppler and ultrasound, although on other occasions it is necessary to resort to other diagnostic techniques such as the CT Angiogram or arteriography.

Objective: The aim of work was to highlight the role of ultrasound and duplex study in evaluation of early complications of the transplanted kidney.

Patients and methods: This study included 30 renal transplant patients who were referred either for routine assessment of the renal allograft or for investigation of the cause of elevated serum creatinine levels. Patients selected from Ahmed Maher Teaching Hospital and Urology and Nephrology Center Mansoura University, in the period from November 2016 to August 2017. The patients were divided into two major groups: Group I: 20 patients with early complicated renal allografts, and Group II (Control Group): 10 patients with normal renal transplant grafts.

Results: The perinephric complications have specific findings on the grey scale ultrasound while the Doppler may not reveal any significant findings. This study revealed that parenchymal complications were the most common early complications to occur after the kidney transplant surgery. The relation between the PSV of either the renal artery or the external iliac artery and the detection of early renal transplant complications in this study was insignificant. Ultrasound and Doppler showed different responses in relation to their specificity and sensitivity in the detection of early renal transplant complications. While Ultrasound was more accurate in detecting urological and perinephric complications showing sensitivity of 100%, Doppler appeared to have the upper hand in the detection of early vascular and parenchymal complications showing sensitivity ranging from 80-100 %.

Conclusion: Doppler indices differ in their specificity and sensitivity in detecting the early renal transplant complications. Doppler indices in different arteries differ in the detection of early parenchymal renal transplant complications. In our study, Resistive index of the interlobar artery proved to be more specific in the detection of early cases of parenchymal complications in a renal transplant patient.

Keywords: Ultrasonography, Doppler, Renal Transplant, Complications.

INTRODUCTION

Chronic kidney disease (CKD) is a worldwide health burden which has an association with high cardiovascular morbidities, decreased quality of life and premature mortalities *(Hill et al., 2017)*. Scientists revealed their intention in having artificial kidneys implanted in end-stage kidney disease patients; thus lowering the dependency on renal transplantation. The new advances in nanotechnology nowadays are putting such an option closer to our grasps; but till then, a successful kidney transplantation will still be the ultimate dream of all end-stage disease patients *(García et al., 2016)*.

Postoperative complications occur in approximately 12%–20% of patients with renal transplants. Post-transplant complications can be divided into categories following the imaging-based classification of renal transplant complications: Perinephric collections, parenchymal abnormalities, abnormalities of the collecting system and vascular complications *(Garcia-Villar et al., 2017)*.

Post-transplant complications can also be divided following the renal transplant's time of evolution: early complications (Acute Tubular Necrosis, Acute Rejection, arterial or venous thrombosis, obstruction, urinary leak, post-transplantation collections and infection); late complications (Transplant Artery Stenosis, Arteriovenous Fistulas, drugs toxicity, chronic rejection and urinary tract infection) *(Garcia-Villar et al., 2017)*.

Whilst kidney graft dysfunction could present with an elevated serum creatinine level, oliguria or pain over the graft site, it could also be asymptomatic. Imaging techniques plays an important role in the detection of anatomical as well as functional abnormalities in the early stages, thus allowing the chance for early treatment, as well as in the late post-transplant period *(Garcia-Villar et al., 2017)*.

The increased frequency of transplantation coupled with increased patient survival have made it necessary for radiologists in all practice settings to be familiar with the normal ultrasound appearance and the imaging findings of common complications associated with renal transplantation (Garrouche et al., 2017).

Radiologists must know about post-renal transplant complications, since it is essential to respond with early treatment, which improves the prognosis of the transplanted kidney *(Garcia-Villar et al., 2017)*.

Doppler Ultrasound (US) is often the modality of choice for primary evaluation of renal transplants in the peri-operative period and in follow-up, *(Garrouche et al., 2017)*. However, there are several limitations to US including its inability to assess renal function or differentiate the causes of parenchymal abnormalities. On other occasions it is necessary to resort to other diagnostic techniques such as the CT Angiogram or arteriography, *(Garcia-Villar et al., 2017)*.

Doppler and ultrasound role in the evaluation of early complications is of paramount importance as it is noninvasive, relatively inexpensive, does not require intravenous contrast, can be

obtained at the bedside, and can often rapidly and accurately depict many of the common complications most notably, vascular complications. The basic points for a thorough and accurate US evaluation, requires an understanding of the exact post-surgical anatomy. A systematic approach can be utilized to ensure that the vast majority of the possible complications are detected; subdivided into the evaluation of 4 points: the transplant perinephric space, the renal parenchyma, the urinary collecting system, the renal vasculature *(Garrouche et al., 2017)*.

The aim of work was to highlight the role of ultrasound and duplex study in evaluation of early complications of the transplanted kidney.

PATIENTS AND METHODS

This prospective study was carried on 20 patients with early renal transplantation complications who performed Ultrasound Doppler examination within one month of renal transplantation. Patients selected from Ahmed Maher Teaching Hospital and Urology and Nephrology Center Mansoura University, in the period from November 2016 to August 2017.

Another 10 patients with no renal transplantation complications who performed Ultrasound and Doppler examination within one month of the renal transplantation were taken as control study group.

The age of the patients ranged from 16-66 years (Mean Age is 46 years). The gender of the patients were 17 (seventeen) males and 13 (thirteen) females.

Inclusion criteria: Recipients of allogenic renal transplants of any age group and sex, when there is clinical and biochemical evidence of deteriorating renal function, where renal function has been poor since transplantation (from 1 day to 1 month after surgery).

Exclusion criteria: No evidence of deteriorating renal function by laboratory investigations or by clinical examination, more than 1 month since renal transplantation surgery, and unstable irritable patients.

All patients included in this study were seeking medical advice after renal transplant surgery and were subjected to:

1. **Clinical assessment:** Complete history taking with emphasizing on history of the postoperative course in details: Personal data, present history, date of the surgery, and postoperative complaints.
2. **Laboratory assessment:** (routine and general evaluation tests)

- Kidney function tests: Blood urea nitrogen, and serum creatinine.
- Complete blood count (CBC).

3. **Radiological assessment:** Ultrasound examination of the transplanted kidney including Doppler examination was performed.

Steps:

1. Examinations performed with a 3.5 MHz real-time sector scanner.
2. The entire renal transplant was scanned on both long and short axes.
3. Attention to renal morphology to identify the features of rejection/other pathologies.

4. The presence or absence of separation of the renal echoes to identify hydronephrosis was noted.
5. The Doppler signal was sampled from two sites: The main renal artery at the hilum and the interlobar arteries.
6. The angle between the ultrasound beam and the vessel under study was altered to achieve the maximal Doppler shift frequency for each vessel.
7. Images of the real-time and of the Doppler frequency spectrum were recorded.
8. The peri-renal area was carefully examined to identify the presence of fluid collections.
9. Results were compared with clinical and biochemical status, histopathology when available.

Statistical Analysis:

Data were checked, entered and analyzed using SPSS version 23 for data processing. The following statistical methods were used for analysis of results of the present study. Data were expressed as number and percentage for qualitative variables and mean + standard deviation (SD) for quantitative one. The arithmetic mean (±) as an average describing the central tendency of observations. The student "t" test for comparison of means of two independent groups. The results of the "t" value was then checked using student "t" table at degree of freedom (df=n1 +n2 – 2) to find out the level of significance (p-value). Mann Whitney test was used to calculate difference between quantitative variables in not normally distributed data in two groups. Chi- square test (X2) used to find the association between row and column variables. Z-test for percentage: to compare percentage of outcome between the two groups. Odds ratio (OR): Compares the odds or the risk that a disease will occur among individuals who have a particular characteristic or who have been expressed to a risk factor to the Odds that the disease will occur in individuals who lack the characteristic or have not been exposed. For all above-mentioned statistical tests done, the threshold of significance was fixed at 5% level (P-value). P-Value $\leq$ 0.05 was considered to indicate significance.

RESULTS

Twenty renal transplant patients were recruited from Ahmed Maher Teaching Hospital and other transplantation centers and were assessed for early detection of allograft complications using a grey scale ultrasound examination of the graft, CDUS and power Doppler and were taken as Group (I). Another Ten renal transplant recipients, recruited from the same centers, who had no renal transplant complications were taken as study control and named Group (II). Radiological results and clinical outcomes for all cases were collected within one month of the renal transplant surgery. A follow-up was also done to some selected cases during this month. Data were reviewed and results were then evaluated using statistical methods.

We classified group (I), transplant recipients with different types of early

complications, for more detailed analysis into:

a. Patients with parenchymal complications: Ten (50%) out of the twenty patients with early renal complications had parenchymal complications including five patients with ATN (25%) and five patients (25%) with acute rejection **(Figure 1)**.

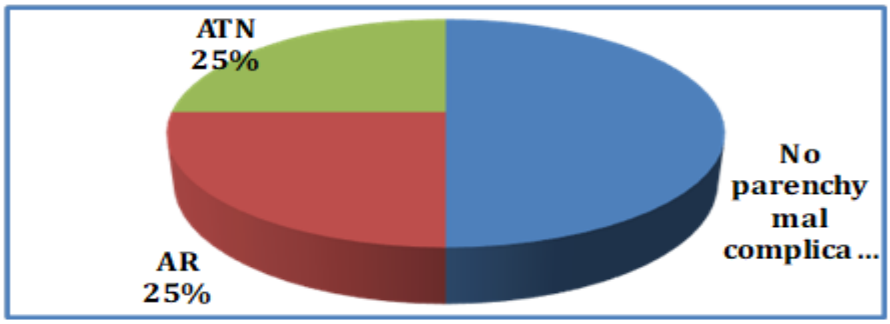

Figure (1): Acute rejection (AR), and acute tubular necrosis (ATN) among the study sample of group (I)

b. Patients with vascular complications: Two (10%) out of the twenty patients with early renal complications had vascular complications including one patient with renal artery thrombosis (5%) and one patient (5%) with renal vein thrombosis **(Figure 2)**.

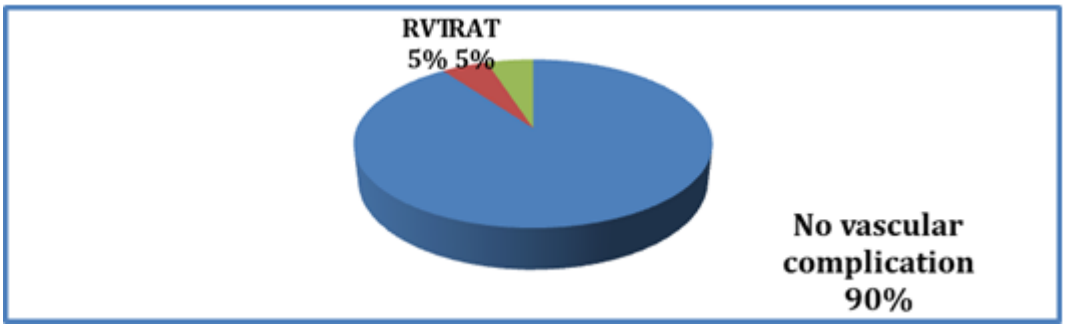

Figure (2): Distribution of renal vein thrombosis (RVT), and renal artery thrombosis (RAT) among the study sample of group (I).

c. Patients with urological complications: Two (10%) out of the twenty patients with early renal complications had urological complications in the form of urine leak due to ureteral leak **(Figure 3)**.

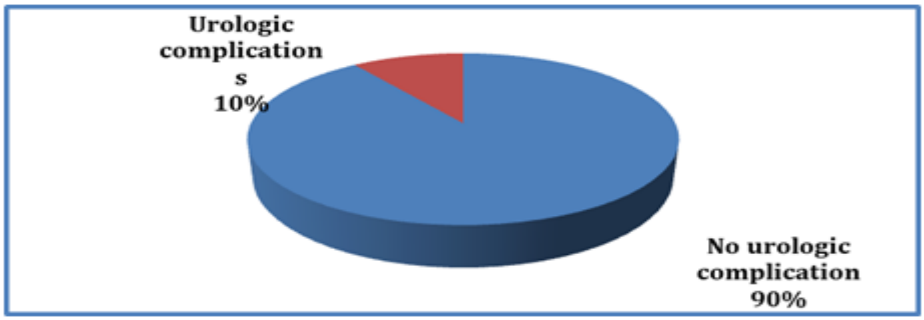

Figure (3): Distribution of urologic complications among the study sample of group (I)

d. Patients with perinephric collections: Eight (40%) out of the twenty patients with early renal complications had perinephric complications including a patient with urinoma (5%), a patient with lymphocele (5%), five patients with hematoma (25%) and a patient with pus (5%) **(Figure 4)**.

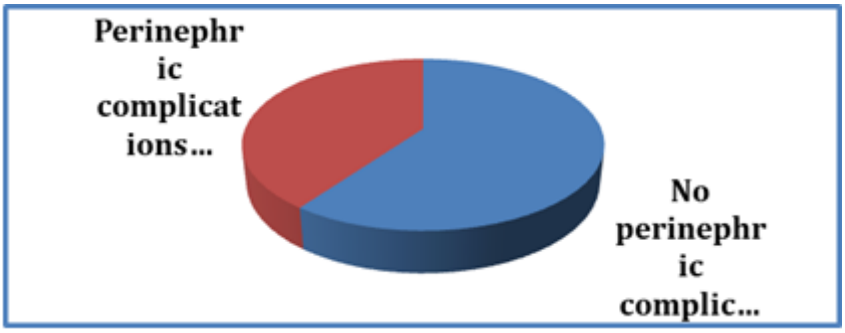

Figure (4): Distribution of perinephric complications among the study sample of group (I)

Two of the included patient population had double renal graft complications:

- One of the patients with AR had superadded complication (had a perinephric collection).
- One patient with ATN had superadded complications (had perinephric graft collections).

Normal functioning renal transplant:

All the normal functioning renal allografts included in this study were located in the right iliac fossa, they had a mean size of 11x4.6x5.1 cm in their longitudinal, AP and transverse diameters respectively. They had a mean parenchymal thickness of 1±0.2 cm. They all had a normal parenchymal echogenicity and cortico-medullary differentiation. All cases had normal medullary pyramids and renal sinus echoes. The mean Doppler indices measured from the intrarenal vessels in these cases were a main renal artery resistivity index (RI) of 0.61±0.08, interlobar resistive index of 0.62±0.07 and a pulsatility index (PI) of 1.4±0.47. The mean peak systolic velocities (PSV) measured from the main renal arteries 166±21.8cm/s.

Parenchymal Renal Transplant Complications:

Table (1) summarizes the mean sizes of the renal grafts seen in the different parenchymal transplant complications.

The renal graft sizes were larger in cases of acute rejection when compared with those with ATN **(Table 1)**.

Table (1): Mean sizes of the renal grafts (in cms) in relation to parenchymal

	Longitudinal	AP	Transverse	Parenchymal thickness
AR (n=5)	11.4±1.0	5.1±0.3	5.8±0.8	1.6±0.2
No AR (n=15)	11.1±1.3	5.6±1.1	5.6±0.6	1.4±0.3
p value	0.570	0.541	0.662	0.061
ATN (n=5)	11.2±1.6	5.0±0.3	5.8±0.6	1.5±0.2
No ATN (n=15)	11.2±1.1	5.6±1.0	5.6±0.7	1.5±0.3
p value	0.760	0.081	0.600	0.760

AR: acute rejection; ATN: acute tubular necrosis; AP: anteroposterior

There was no significant relation was seen between the measured renal length and the detection of parenchymal renal disease **(Table 2)**.

Table (2): Summarizes that sensitivity, specificity, positive and negative predictive values of measurement of the renal allograft length by gray scale ultrasound in detection of the different types of medical allograft complications

Complication	Marker	Cutoff value	Sensitivity	Specificity	PPV	NPV
AR	**Longitudinal**		50%	21%	3%	89%
ATN	**Longitudinal**		51%	21%	3%	9%

AR: acute rejection; ATN: acute tubular necrosis; P. thickness: parenchymal thickness; PPV: positive predictive value; NPV: negative predictive value.

The table shows that in cases of acute rejection, the RI of the main renal artery is 0.81±0.06 while the RI of the interlobar arteries is 0.79±0.05. The PI of the main renal artery was 1.79±0.41 in those cases. While in the cases of ATN, the RI of the main renal artery is 0.82±0.11 while the RI of the interlobar arteries is 0.82±0.13. The PI of the main renal artery is 1.7±0.2 in those cases **(Table 3)**.

Table (3): Mean RI (main renal artery), PI (main renal artery, and RI (interlobar artery) in relation to parenchymal complications

	RI (main RA)	PI (main RA)	RI (ILA.)
AR (n=5)	0.81±0.06	1.79±0.41	0.79±0.05
No AR (n=15)	0.74±0.10	1.53±0.31	0.70±0.13
ATN (n=5)	0.82±0.11	1.7±0.2	0.82±0.13
No ATN (n=15)	0.74±0.08	1.6±0.4	0.69±0.10

AR: acute rejection; ATN: acute tubular necrosis; RA: renal artery; ILA: interlobar artery

The cutoff value of RI of main renal artery in acute rejection was the same as the cutoff value of RI in interlobar artery. However, at the same cutoff value, the specificity of RI of interlobar artery (69.23%) was higher than the specificity of RI of main renal artery (61.54%) in detecting acute rejection of the allograft. In the shared cutoff value, the sensitivity of RI of both arteries in acute rejection detection was 100%. Meanwhile, higher RI of both arteries shows more specificity in detecting acute rejection. When the cutoff value was 0.775, the specificity of RI in main renal artery was 69.23% while the specificity of RI in interlobar artery was 77%.

The cutoff value of RI of main renal artery in acute tubular necrosis was 0.755, while the cutoff value of RI in interlobar artery in the same complication was 0.765. At these values, the sensitivity of RI in both arteries was 80 % in detection of acute tubular necrosis, whereas the specificity of RI of interlobar artery (76.92 %) was higher than that of main renal artery which was 61.54% in detecting acute tubular necrosis **(Table 4)**.

Table (4): Summarizes the cutoff values, sensitivity, specificity, positive and negative predictive values of Doppler indices of the renal allograft in detection of the different types of parenchymal transplant complications

Complication	Marker	Cutoff Value	Sensitivity	Specificity	PPV	NPV
AR	RI (main RA)	0.74	100%	61.54%	50%	100%
	PI (main RA)	10.715	60%	76.92%	50%	83.33%
	RI (ILA)	0.740	100%	69.23%	55.56%	100%
ATN	RI (main RA)	0.76	80%	61.54%	44.44%	88.89%
	PI (main RA)	1.695	60%	61.54%	37.5%	80%
	RI (ILA)	0.765	80%	76.92%	57.14%	90.91%

AR: acute rejection; ATN: acute tubular necrosis; P.thickness: parenchymal thickness; PPV: positive predictive value; NPV: negative predictive value; RA: renal artery; ILA: interlobar artery

The table shows that in cases of acute rejection, the PSV of the main renal artery is 172.0±17.7while the PSV of the external iliac artery is 126.2±29.2. While in the cases of ATN, the PSV of the main renal artery is 154.8±49.1while the PSV of the external iliac artery is 123.6±43.7 **(Table 5)**.

Table (5): Summarizes the PSV measured from the main renal artery and the external iliac arteries in the different parenchymal transplant complications

	PSV (RA)	PSV (EIA)
AR(n=5)	172.0±17.7	126.2±29.2
No AR(n=15)	176.6±50.0	125.2±49.0
ATN(n=5)	154.8±49.1	123.6±43.7
No ATN(n=15)	182.8±40.4	126.1±45.5

AR: acute rejection; ATN: acute tubular necrosis; RA: renal artery; EIA: external iliac artery

No significant differences were seen between the measured PSVs in cases of parenchymal renal disease. Two cases of the ten cases of parenchymal renal transplant complications in our study ended up in graft loss **(Figure 5)**.

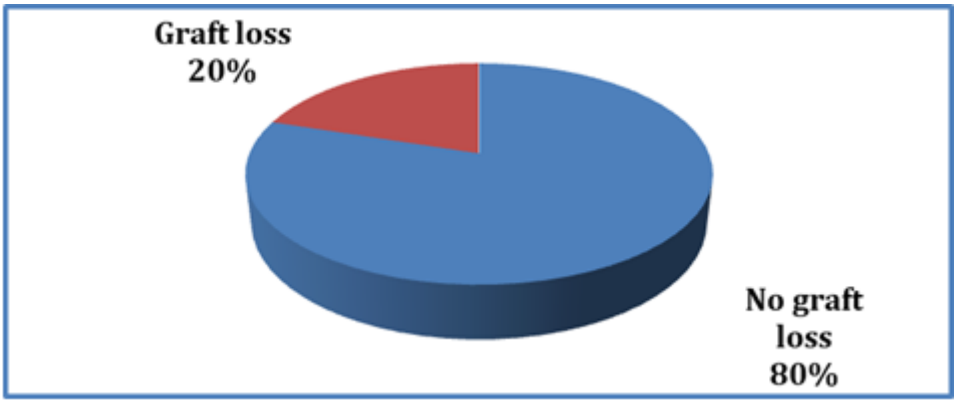

Figure (5): Pie chart showing percentage of graft loss.

Vascular Renal Transplant Complications:

The two cases of vascular renal transplant complications in our study had an outcome of graft loss.

The Doppler was 100% sensitive and specific in detecting the early vascular complication whether by the detection of absent blood flow in RAT or by detecting other specific findings such as reversed diastolic flow in case of RVT.

Renal artery thrombosis:

The case of renal artery thrombosis seen in our study had a normal renal size of 10.17 x 5.14 x 5.22 cm in its longitudinal, AP and transverse diameters with a mean parenchymal thickness of 1.42cm. It showed a normal parenchymal echopattern with no pelvicalyceal dilatation. Evidence of absent vascularization of the transplanted kidney is noted.

The intrarenal Doppler indices and the PSV at both transplanted renal artery and external iliac artery were not applicable.

Renal vein thrombosis:

The case of renal vein thrombosis seen in our study had a normal renal size of 10.22 x 5.21 x 5.19 cms in its longitudinal, AP and transverse diameters with a mean parenchymal thickness of 1.36cm. It showed a normal parenchymal echopattern with no pelvicalyceal dilatation.

The intrarenal Doppler indicesmeasurments were not usually applicable.

The wave morphology of renal vein thrombosis showed evidence of reversed diastolic flow.

Perinephric Renal Transplant Complications:

- Eight of the examined cases (40% of the total complications) had perinephric transplant collections with their durations ranging from 1 day to 1 month from the time of the transplantation. The volumes of these collections ranged from 10cc to 715cc.
- Five of these cases (62.5% of the collections) proved to be hematomas upon aspiration and their duration from the time of transplantation ranged from 1 day till 15 days. The cases of hematoma showed increased echogenicty by the grey scale ultrasonography. One of the hematoma cases were seen compressing the external iliac vein, causing lower limb edema.

- One case (12.5% of the collections) proved to be urinoma after aspiration which developed after 5 days from the transplant date. It appeared as fairly ill-defined hypoechoic collections in the vicinity of the renal grafts.
- One case (12.5%) of the transplant collections proved to be pus upon aspiration and its duration was 18 days from the time of transplantation. It appeared clinically with fever and graft tenderness. It appeared as well-defined hypoechoic collection. The pus and urinoma could not be differentiated by ultrasound examination alone.
- One case (12.5%) of the transplant collections proved to be lymphocele, with duration of 30 days from the time of transplantation. The case appeared as well-organized collections in the region of the renal grafts, and it appeared as heterogeneous hypoechoic collection with internal septations seen within.

The renal grafts all appeared of normal size, shape and smooth cortical outline and echogenicity, their mean length was 11.12±0.8cm, their mean AP diameter was 5.1±0.6cm and their mean transverse diameters was 5.4±0.64 cm with a mean cortical thickness of 1.21±0.3 cm. The Doppler indices measured from the intrarenal vessels of these grafts were within the normal range, having a mean RI of 0.65±0.07, a mean PI of 1.22±0.26.

All the renal transplant recipients who had perinephric complications were managed successfully by either aspiration drainage or follow up.

Urological RenalTransplant Complications:

Two cases (10%) had urine leak. The lesion appeared as free hypoechoic collection in the area of renal graft. The renal grafts all appeared of normal size, shape and smooth cortical outline and echogenicity, their mean length was 11.23±0.7cm, their mean AP diameter was 5.4±0.5cm and their mean transverse diameters was 5.2±0.67 cm with a mean cortical thickness of 1.17±0.4 cm. The Doppler indices measured from the intrarenal vessels of these grafts were within the normal range, having a mean RI of 0.65±0.08, a mean PI of 1.22±0.24.

Case (1)

History: Male patient 52 years old, with hypertension and CKD, presented 5 hours post transplantation with anuria, abdominal pain and lower limb edema. His blood pressure was 160/120 mmHg and his creatinine was raised (2.6 mg/dL).

Ultrasound Examination: The right iliac fossa transplanted kidney is seen of average size "10.42 x 5.21 x 5.18 cm, showing normal parenchymal echogenicity with preserved cortico-medullary differentiation **(Figure 6a)**.

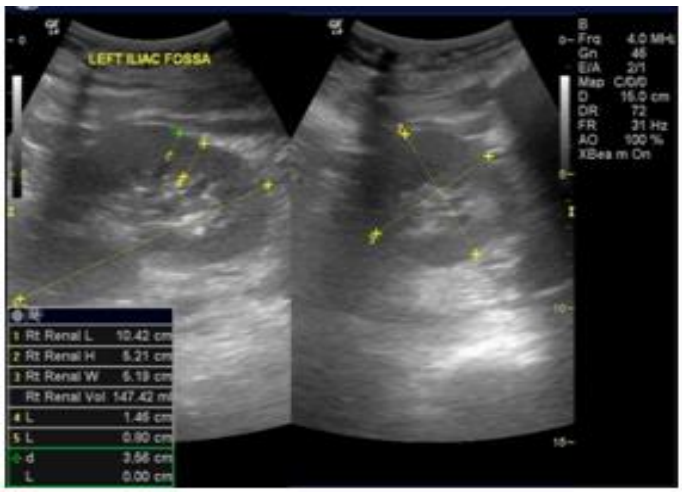

Figure (6a): Grey scale ultrasonography of transplanted kidney in case of RVT

Doppler findings:

- No flow could be noted in the renal vein? Thrombosed, occluded.
- Evidence of reversed diastolic flow impressive of renal vein thrombosis **Figure (6b)**.

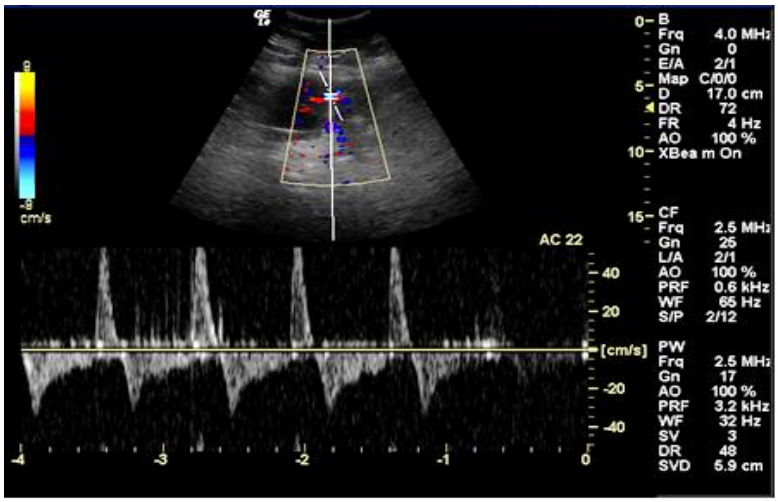

Figure (6b): Doppler indices in case of RVT

Radiological opinion: Renal vein thrombosis?
Management: exploration where the vein was occluded due to kink and compression.
Outcome: Graft Loss.

Case Presentation (2)

History: 45-year-old male patient with history of TIA, hypertension and CKD. Presented 1 day post transplantation with oliguria, blood pressure of 170/100 mmHg and raised creatinine level (2.5 mg/dL).

Ultrasound Examination: The right iliac fossa transplanted kidney is of average size "11.49 x 5.32 x 6.24 cm, volume 200 ml, parenchyma 1.35 cm, cortex 0.83 cm", showing normal parenchymal echogenicity with preserved cortico-medullary differentiation. No evidence of renal stones, cysts, or backpressure changes **(Figure 7a)**.

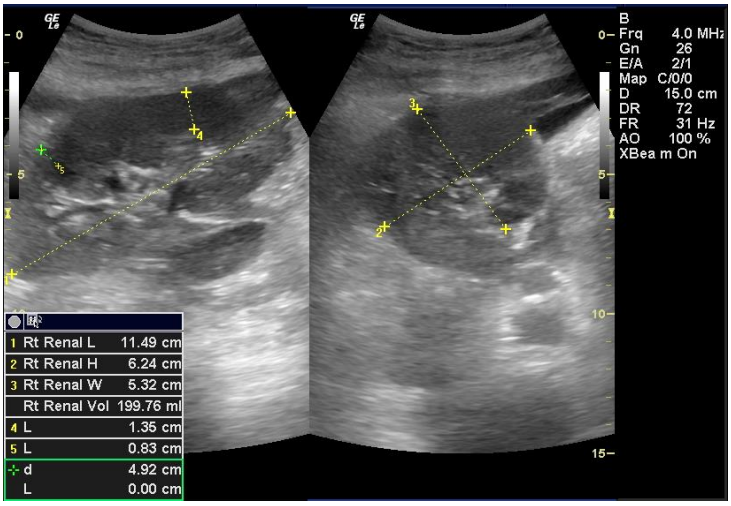

Figure (7a): Grey scale ultrasound of transplanted kidney

Doppler findings:

- Transplanted kidney appeared non vascularized. (Figure 7b)
- Occluded renal artery.
- Patent renal vein. (Figure 7c).

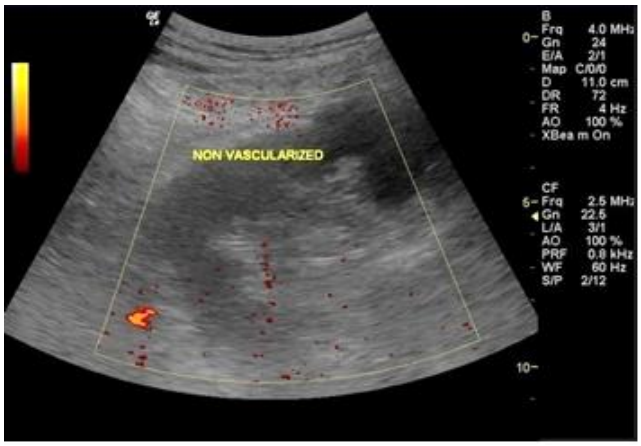

Figure (7b): Non vascularized kidney impressive of renal artery thrombosis

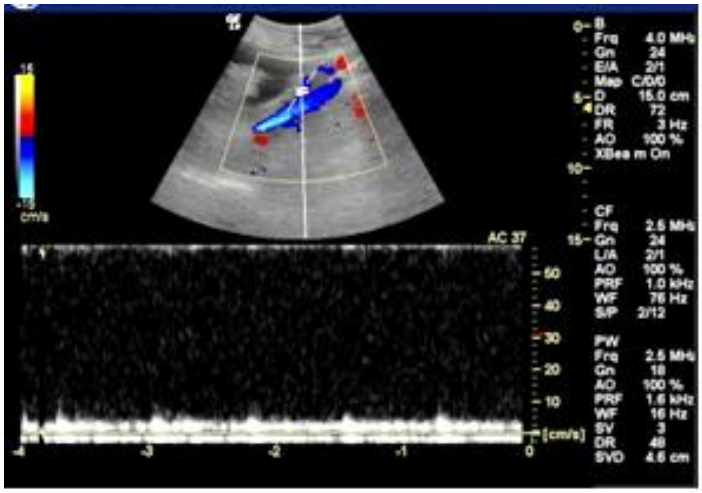

Figure (7c): Patent renal vein

Management: exploration on site.
Outcome: graft loss.

DISCUSSION

Our study bears the advantage of being a prospective study. It was performed using a grey scale ultrasound examination, Color Doppler US (CDUS) and Power Doppler. Thirty Egyptian renal transplant recipients were included in this study. Ten of them were taken as control, while the other twenty patients were kidney transplant recipients with complications. All were being donated from Living Donors.

Doppler and Ultrasonography evaluations were done within the first month of the renal transplant surgery. A follow-up was also done to some selected cases. Data were reviewed and results were then evaluated using statistical methods.

Patients were divided into two groups according to their kidney transplant status: **Group I:** Recipients with an abnormal kidney transplant duplex representing 20 out of 30 patients (66.7%). **Group II:** Recipients with a normal kidney transplant representing 10 out of 30 patients (33.3%).

Recipients in Group I was sub-divided into:

a. Patients with parenchymal complications.
b. Patients with vascular complications.
c. Patients with Urological complications.
d. Patients with perinephric complications.

This study revealed that the early parenchymal complications which can occur within a month of the post-transplant surgery include ATN and AR. This confirms *Rodgers et al. (2014)* work highlighting the timing of disease presentation as an important factor in diagnosing the causes of diminished renal transplant function and that acute tubular necrosis and acute rejection are the only parenchymal complications which can happen during the first month of the allograft transplant.

Gray-scale ultrasonography findings were nonspecific and subjective, in patients who had parenchymal complications in our study, with negative predictive values 89% and positive predictive value of 3%. This confirms *Galgano et al. (2018)* work saying that there are several limitations and missing abilities of an ultrasound examination and that not all complications could be detected by ultrasonography.

Patients who had ATN in our study presented to us in the first week post-operative and usually resolves within two weeks. These findings have similar results as of *Garcia-Villar et al. (2017).*

Meanwhile, this study revealed that renal recipients with acute rejection experienced the aforementioned complication 7-20 days after the operation. These results were similar to that of *Garcia-Villar et al. (2017).*

ATN and AR were the most common cause of impaired renal function in the early post-transplant period. These results were similar to *Garcia-Villar et al. (2017)* who found that ATN is the most common cause of impaired renal function in the early post-transplant period, while acute rejection is the most common type of allograft rejection, affecting up to 40% of patients with renal transplants.

The RI cutoff value for parenchymal complication in our study was ranging from 0.745-0.765 which correlates with *Garrouche et al. (2017)* work who says that less than 0.7 is considered normal.

The RI cutoff value in the main renal artery and the interlobar artery was 0.74 in recipients who had acute rejection, being specific by 61.9% and 69.23% respectively in detection of acute rejection. However, when the RI increases to higher value, for example 0.775, the specificity of RI in detection of acute rejection in both (main renal artery and interlobar artery) increases to 69.23% and 77% respectively. This means that higher RI is more specific in detecting acute rejection. These findings are similar to *Rodgers et al. (2014)* study who found that the likelihood of acute rejection increases with higher RIs.

Our study revealed that while the cutoff value of RI in early parenchymal complications is ranging from 0.74-0.765, the sensitivity of 80% and a specificity of 61.9% in main renal artery and a sensitivity of 80% and a specificity ranging from 69.23%-76.92% In interlobar artery, should definitely be alarming. However, renal biopsy was the gold standard in differentiating between both types of early parenchymal complications which correlates with *Rodgers et al. (2014)* results who said that ultimately biopsy is necessary for diagnosis in an overwhelming majority of cases.

This study certainly revealed that the specificity of RI in the interlobar artery in detection of early parenchymal complications at the same cutoff value is higher than the specificity of RI in the main renal artery in detecting the same complication.

The above results could somehow lead physicians to emphasis on the role of intralobar artery with an elevated R.I. value in the detection of early parenchymal complications, considering it more specific than the main renal artery.

In our study, renal artery thrombosis and renal vein thrombosis account for the vascular complications that can happen during the first month after the kidney transplant surgery. Both usually have poor outcome and may result in graft loss. In our study, both cases had graft loss.

Lymphoceles, pus, urinomas and hematomas are the perinephric complications that occurred in the renal transplant recipients during the first month in our study.

The perinephric complications have specific findings on the grey scale ultrasound while the Doppler may not reveal any significant findings.

This study revealed that parenchymal complications were the most common early complications to occur after the kidney transplant surgery.

The relation between the PSV of either the renal artery or the external iliac artery and the detection of early renal transplant complications in this study was insignificant.

Two out of the 20 patients recruited in this study were indicated for a renal biopsy in their early post-operative first week hospital stay.

Most of the renal graft parenchymal complications show complete recovery, while a minority (20%) of patients with parenchymal complications experienced graft loss.

In agreement with *McArthur et al. (2011)* who found that a RI value of more than 0.74 between the first week post-transplantation is associated with graft dysfunctions, further clinical trials for early manipulation of immunosuppression protocols along with aggressive blood pressure control and even considering a renal biopsy at a lower RI threshold value should be considered in a trial to avoid upcoming transplants' failures.

The Doppler was 100% sensitive and specific in detecting the early vascular complication whether by the detection of absent blood flow in RAT or by detecting other specific findings such as reversed diastolic flow in case of RVT. These results confirm the results of *Granata et al. (2015)* who found that Doppler ultrasound is highly specific in detecting vascular complications of a transplanted kidney and can also display high diagnostic accuracy.

Eight of the examined complicated cases (40% of the total complications) had perinephric transplant collections with their durations ranging from 1 day to 1 month from the time of the transplantation. In *Garrouche et al. (2017)* study it was clearly pointed to that the Perinephric fluid collections are a common occurrence, and are found in ≤50% of renal transplants. Ultrasound was an excellent tool to detect the presence of perinephric collection and gave a clue about the type of complication (blood, lymph or pus), however, aspiration was the ultimate tool in distinguishing between the different fluid types as well as managing it.

Differentiating between the case of pus and urinoma solely by ultrasound was somehow difficult and aspiration drainage was performed to aid knowing the type of fluid inside. This finding correlate with *Garcia-Villar et al. (2017)* who claimed that the appearance of urinoma by US is

not specific and drainage may be performed with US guidance.

Lymphocele occurred 29 days post-operation and showed internal septations by ultrasound which confirms Garcia-*Villar et al. (2017)* description of Lymphocele.

Supported by *Aneesh et al. (2013)* who said that despite an early diagnosis it is still difficult to salvage a graft with vascular complication resulting in its loss, 2 (100%) patients out of the 2 patients who had vascular complications in our study lost their grafts even after having a re-anastomosis surgery.

CONCLUSION

Although there are several limitations to ultrasound, as its missing abilities in differentiating between causes of renal dysfunctions as acute tubular necrosis and drug toxicity, many of the major complications after a renal transplant such as vascular complications and post-operative collections could be detected by ultrasound imaging, making it the first line for an early diagnosis.

Careful management of complications surely prevents the premature loss of a renal transplanted graft and reduces morbidity and mortality.

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دور الموجات فوق الصوتية و الدوبلر الملون في تشخيص مضاعفات ما بعد زراعة الكلى

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خلفيـــة البحـــث: يمكـــن تشـــخيص مضـــاعفات زرع الكلـــى وعلاجهـــا باســـتخدام تقنيـــات تضـــمن الحـــد الأدنـــى مـــن التـــدخل الجراحـــي. يجـــب أن يعـــرف طبيـــب الأشـــعة عـــن مضـــاعفات زراعـــة الكلـــى، لأنـــه مـــن الضـــروري أن يـــتم الكشـــف المبكـــر لضـــمان الإســـتجابة المرجـــوة للعـــلاج، الأمـــر الـــذي قـــد يحســـن مـــن فـــرص تعـــافي الكلـــى المزروعـــة. يمكـــن الكشـــف عـــن معظـــم المضـــاعفات عـــن طريـــق الـــدوبلر الملـــون والموجـــات فـــوق الصـــوتية، مـــع الأخـــذ فـــي الإعتبـــار أنـــه فـــي مناســـبات أخـــرى مـــن الضـــروري اللجـــوء إلـــى تقنيـــات تشخيصـــية أخـــرى مثـــل تصـــوير الأوعيـــة الدمويـــة أو التصوير الشعاعي للشرايين.

الهـــدف مـــن البحـــث: مراجعـــة المضـــاعفات المبكـــرة ومـــا يتعلـــق بـــدور الموجـــات فـــوق الصـــوتية والـــدوبلر الملـــون ودور الأشـــعة التداخليـــة فـــي تشـــخيص وعـــلاج خلـــل وظـــائف الكلى المزروعة.

المرضـــي وطـــرق البحـــث: شـــملت هـــذه الدراســـة ثلاثـــين مريضـــاً مـــن زرع الكلـــى الـــذين تمـــت إحـــالتهم إمـــا لتقيـــيم روتينـــي للكلـــى المزروعـــة أو للتحقيـــق فـــي ســـبب ارتفـــاع مســـتويات الكريـــاتينين (وظـــائف الكلـــى). تـــم إختيـــار المرضـــى مـــن مستشـــفى أحمـــد مـــاهر التعليمـــي ومركـــز أمـــراض الكلـــى والمســـالك البوليـــة بجامعـــة المنصـــورة ، فـــي الفتـــرة مـــن نـــوفمبر 2016 إلـــى أغســـطس 2017. وتـــم تقســـيم المرضـــى إلـــى مجمـــوعتين رئيســـيتين: المجموعـــة الأولـــى (مجموعـــة المراقبـــة): عشـــرة مرضـــى لا يعـــانون مـــن أي مضـــاعفات للكلـــى المزروعـــة. المجموعـــة الثانيـــة: عشـــرون مريضـــاً يعـــانون مـــن مضاعفات في الكلى المزروعة.

نتـــائج البحـــث: وأظهـــرت الموجـــات فـــوق الصـــوتية والـــدوبلر اســـتجابات مختلفـــة فيمـــا يتعلـــق بخصوصـــية وحساســـية كـــلا الفحصـــين فـــي الكشـــف عـــن مضـــاعفات زرع الكلـــى

في وقت مبكر. في حين أن الموجات فوق الصوتية كانت أكثر دقة في الكشف عن المضاعفات البولية والمحيطة بالكلى المزروعة والتي أظهرت حساسية ١٠٠٪، بدا أن الدوبلر الملون له اليد العليا في الكشف عن مضاعفات الأوعية الدموية ومضاعفات نسيج الكلى المبكرة التي تظهر حساسية تتراوح بين ٨٠ إلى ١٠٠٪.

الاستنتاج: تختلف مؤشرات فحص الدوبلر الملون في خصوصيتها وحساسيتها في الكشف عن مضاعفات زرع الكلى المبكرة. أيضاً، تختلف مؤشرات فحص الدوبلر الملون في الشرايين الكلوية المختلفة في الكشف عن مضاعفات نسيج الكلى المزروعة في وقت مبكر. في دراستنا ، أثبت مؤشر المقاومة للشريان البيني أنه أكثر تحديدًا في الكشف عن الحالات المبكرة للمضاعفات النسيجية في مريض زرع الكلى.

الكلمات الدالة: الموجات فوق الصوتية، دوبلر، زراعة الكلى، المضاعفات.