Complications of renal transplantation: Diagnosis and treatment

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Learning objectives

1. To describe the characteristic features of renal transplantation complications.
2. To establish radiological management for each and treatment to be administrated.
3. To review the applications of interventional radiology to manage of renal transplantation complications.
Background

Renal transplantation is considered a treatment of choice in cases of chronic renal failure. Whilst kidney transplant dysfunction can present with an elevated rising serum creatinine level, decreasing urine output and pain and tenderness over the graft, often it is clinically asymptomatic and presents only with an isolated increase in serum creatinine.

Advances in imaging techniques have played a great role in early detection and management of the anatomical and functional abnormalities of the graft in the early stages as well as in the late post transplant period. Therefore, radiologists have a key role in assessing renal transplantations because it is important to establish an early diagnosis of complications, since most are potentially treatable.

ANATOMY AND TECHNIQUE

The transplanted kidney is usually placed extraperitoneally. The right iliac fossa is usually preferred, since the right iliac vein runs a more superficial and horizontal course on this side of the pelvis, making the creation of vascular anastomoses easier.

Vascular anastomosis is most commonly made with external iliac vessels:

- Arterial Anastomosis (Figure 1): In patients who receive cadaveric transplants, the donor renal artery is obtained along with a portion of the aorta (Carrel patch) and is anastomosed end-to-side to the recipient external iliac artery. In cases of living donors, only the main renal artery is obtained with the kidney and is anastomosed either end-to-side to the external iliac artery or end-to-end to the internal iliac artery. In cases of multiple renal arteries of the donor kidney, either a long "Carrel patch" containing both renal arteries may be obtained or separate patches may be obtained.
- Venous anastomosis: Venous anastomoses are almost always placed end-to-side to the external iliac vein. In case of multiple renal veins, usually the larger vein is anastomosed and the smaller veins are ligated.
- Ureteral anastomosis. The most common method is the creation of a ureteroneocystostomy. Other, less commonly employed techniques include an uretero-ureterostomy or a pyelo-ureterostomy.

IMAGING EVALUATION

In the immediate post-transplant period, ultrasound (US) helps to establish the renal size and echogenicity, the status of the collecting system and ureter, and the size and location of any postoperative para-renal fluid collections.
The appearance of a normal transplanted kidney (Figure 2) may appear slightly different than that of a normal native kidney because of its relatively superficial location. Apparently in the transplants, there is an improved corticomedullary differentiation; the medullary pyramids appearing relatively hypoechoic and the cortex appearing relatively brighter. The colour Doppler ultrasound is performed to evaluate vascular flow in the renal and iliac vessels and to determine the perfusion of the kidney. The spectral waveform is routinely used to establish the baseline velocities and waveform patterns. Various indexes are used to evaluate the flow resistance, including resistive index, pulsatility index, and systolic/diastolic ratios. US also plays a very useful role in guiding the interventional procedures. Most institutions are now using real-time US guidance to direct a renal biopsy.

Contrast-enhanced ultrasound is a non-invasive technique that can be performed at bedside. At 15-45 seconds after contrast infusion, the graft is enhanced. With this procedure, we can get an excellent image of the graft vascularization and kinetics can be explored.

Radionuclide imaging (Figure 3) is also one of the main modalities used to evaluate renal transplants and is frequently used to assess the renal function, radiotracer excretion, and urological abnormalities, such as ureteral obstruction or urine leak.

CT scanning has a limited value in evaluating renal transplants because the use of iodinated contrast is usually avoided due to nephrotoxic effects. A noncontrast CT may be useful to assess the extent of a perinephric fluid collection and its anatomic relationship to the kidney. However, CT is a useful tool for interventional management of some complications, such as drainage placement or percutaneous nephrostomy.

MRI can provide excellent anatomical orientation of the kidney and vessels as well as any perinephric collections. Magnetic resonance angiography (MRA) is sometimes used to evaluate the renal vessels in cases of suspected artery stenosis. The gadolinium contrast in MR should be administered with caution in patients with decreased renal function and low glomerular filtration rate because of the risk of nephrogenic systemic fibrosis.

Conventional angiography is used very selectively to evaluate previously suspected vascular abnormalities based on imaging findings seen on other modalities. In most cases, a percutaneous transluminal angioplasty (PTA) with or without a stent placement is the first line of treatment for an RAS. Thrombolytic therapy may be employed for treating a vascular thrombus. Coiling may be performed for arteriovenous fistulas and pseudoaneurysms.
Fig. 1: Figure 1. Anatomy of the Renal transplant. Drawings illustrate arterial anastomosis of a renal transplant with one renal artery. The renal artery is anastomosed either end-to-side to the external iliac artery (A) or end-to-end to the internal iliac artery (B). Note that a portion of the aorta (Carrel patch) is harvested with the renal artery in the end-to-side procedure (arrow). Renal veins are anastomosed end-to-side to the external iliac vein. Illustration inspired from Kobayashi K. et al (Ref. 6).

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**Fig. 2:** Grayscale, Colour Doppler and Spectral Doppler ultrasound (US) of a normal transplant kidney. The grayscale US (A) shows a good corticomedullary differentiation. The renal arterial resistance index are normal(B). The renal vein is permeable (C) and peak systolic velocity in the anastomoses is normal (D).

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Fig. 3: Radionuclide imaging with 99m TC-DTPA shows a renal transplant with normal perfusion.

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Findings and procedure details

Postoperative complications occur in approximately 12%-20% of patients with renal transplants.

Posttransplant complications can be divided into five categories following the imaging-based classification of renal transplant complications (Figure 4): Perinephric collections, parenchymal abnormalities, abnormalities of the collecting system, vascular abnormalities and postbiopsy complications.

Posttransplant 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, posttransplantation collections, drugs toxicity and infection); late complications (Transplant Artery Stenosis, Arteriovenous Fistulas, drugs toxicity, chronic rejection and urinary tract infection). Finally, the long-term complications include many forms of glomerulonephritis which may cause recurrent disease in the transplanted kidney, although early recurrence and graft failure are rare (Figure 5).

So, it is also essential to establish the transplant's progression time, as there are acute complications that require urgent attention.

We will discuss cases for each of these, explaining the radiological findings that we should take into account, the treatment administered and the patients' clinical progress.

1.- PERINEPHRIC FLUID COLLECTIONS (Figures 6-12)

Fluid collections around the kidney are very common in the early posttransplant period and these may be seen in up to 50% of cases. Common posttransplant fluid collections include hematomas, seromas, lymphoceles, urinomas and abscesses.

1.1. HEMATOMAS

The overall incidence of significant postoperative hematomas from renal transplant varies from 4 to 8%. They can be subcapsular or perinephric. US findings demonstrate an echogenic fluid collection in the acute phase which become less echogenic over time (Figure 6). Sometimes they have a very complex appearance with multiple septations. Usually, the US is the only test required to diagnose and monitor the hematomas.
However, in patients with hemodynamic instability we need other diagnostic tests like CT to quantify the bleeding (Figure 7).

1.2. LYMPHOCELES

Lymphoceles result from surgical disruption of lymphatics and usually occur 4 to 8 weeks following transplant. Lymphoceles usually occur medial to the transplant, between the graft and the bladder. In grayscale ultrasound they appear as anechoic collections and may have septations (Figures 8-10). Usually these are asymptomatic; however, they occasionally cause hydronephrosis or lower extremity edema. US-guided percutaneous drainage is the recommended first line of treatment (Figure 9).

1.3. SEROMAS

Seromas are liquid collections that are located superficially (below the subcutaneous cellular tissue) (Figure 11). There are no specific findings on seromas in renal transplant patients, but they may be at high risk of infection due to immunosuppression.

1.4. URINOMAS

Urinomas usually occur in the first 2 weeks after transplantation and they are relatively rare complications of transplantation. They are caused by the extravasation of urine from the renal pelvis, the ureter or a ureteroneocystostomy.

Urinomas are extraperitoneal collections and usually they are seen between the kidney and the bladder. These may occasionally rupture intraperitoneally.

Because of the risk of infection in this immunosuppressed state, urine leak is a potentially life-threatening complication. Patients with urine leaks may present with pain, swelling and discharge from the wound.

On US (Figure 12), its appearance is not specific and they are seen as anechoic fluid collections. Drainage may be performed with US guidance and the higher creatinine level of the fluid compared with its serum concentration differentiates a urine leak from a seroma or lymphocele.
Radionuclide scintigraphy exhibits radiotracer activity outside the confines of the urinary system and is very helpful to differentiate urinomas from other collections. Most of the leaks are managed conservatively by percutaneous nephrostomy and stent placement but surgical repair may occasionally be necessary.

2.- PARENCHYMAL ABNORMALITIES (Figures 13-22)

2.1. DIFFUSE

A) ACUTE TUBULAR NECROSIS (ATN)

ATN is the most common cause of impaired renal function in the early posttransplant period. It usually occurs right after the transplantation and resolves within 2 weeks. The initial cause of ATN is usually related to the process of the transplant itself that causes ischemia to the kidney. Gray-scale US findings are non-specific (graft swelling, decreased echogenicity or obscured corticomedullary differentiation). Colour Doppler US may reveal elevated RI and even loss of diastolic component (Figure 13).

B) REJECTION

It is usually classified into hyperacute, acute or chronic, depending on the time of occurrence. Hyperacute rejection is caused by the presence of preformed antibodies in the recipient's serum. Since this happens during or immediately after surgery, it is rarely imaged. Acute rejection is uncommon in the first few days after surgery. It usually occurs 1 to 3 weeks after surgery. Acute rejection is the most common type of allograft rejection, affecting up to 40% of patients with renal transplants. The characteristic radionuclide imaging is similar to ATN with diminished flow. Doppler ultrasound shows no specific findings and radionuclide imaging shows no specific findings in acute rejection (diminished flow and resistive index that exceeds 0.80).

Chronic rejection shows a thin cortex and small size on both gray-scale US (Figure 14) and radionuclide images. Allograft biopsy is usually required to correctly diagnose acute or chronic rejection and to determine prognosis.

Transplantectomy is the best treatment if there are some associated complications such as allograft infection, neoplasia or high risk of graft rupture. However, surgical treatment is not exempt from risk and it is associated with a considerable number of complications (Figure 15). Therefore, it is desirable to use less invasive procedures such as embolisation (Figure 16).
C) PYELONEPHRITIS

In patients with renal transplant and symptoms of urinary tract infection an ultrasound must be carried out. Although the ultrasound is usually normal, some findings could be hypoechogenic areas, increased renal size, hydronephrosis and thickened urothelium (Figure 17). If the patient has a bad clinical evolution, CT must be carried out to exclude complications.

D) BK VIRUS

BK virus nephropathy occurs in up to 5%-10% of kidney transplants, usually within the first 12-18 months of transplantation. US findings are nonspecific, although obstructive features have been reported because of the ureteral involvement of the virus. Serum- and urine-based PCR along with biopsy findings supporting BK virus tubular damage is required for confirmatory diagnosis.

E) DRUG TOXICITY

The commonly used drugs for immunosuppression after transplantation include cyclosporine A, tacrolimus, azathioprine or prednisone or. The US may be completely normal or may show non-specific findings in drug toxicity. Grayscale US may show renal swelling, increased or decreased renal echogenicity, effacement of the renal sinus or loss of corticomedullary differentiation.

2.2. FOCAL

Focal lesions are less commonly seen in renal transplant. Simple or complex cysts (Figure 18) may develop in some cases. Focal contusion or hematoma may occur after surgery or biopsy. Benign renal tumours (Figures 19-20) renal carcinoma or lymphoproliferative disorders may occasionally develop in the graft. Infective lesions such as abscesses (Figures 21-22) or fungal infections may occur. Anatomic imaging such as US or CT may help to evaluate these lesions. Occasionally a needle biopsy may be required for diagnosis.

3.- COLLECTING SYSTEM ABNORMALITIES (Figures 23-31)

3.1. HYDRONEPHROSIS
Urinary obstruction is seen in about 2% cases. Hydronephrosis could be secondary to extrinsic compression of the ureter by perinephric fluid collections. The other causes of ureteral obstructions include stones (Figure 23), papillary necrosis, clots, fungi, pelvic fibrosis, foreign bodies (Figure 24), stenosis (Figure 25), granulomas (Figure 26) and tumours. The US shows dilated renal pelvis and calyces. Increased resistive index may be seen in some cases of obstructive hydronephrosis. Usually, the ureteral obstruction is initially managed by a percutaneous nephrostomy. This helps to decompress the collecting system and increase renal function.

3.2. VESICoureTERAL REFLEX

Vesicoureteral reflux following renal transplantation is common (50-60%) (Figures 27-28). Reflux is largely due to surgical technique. Patients with recurrent pyelonephritis despite antimicrobial prophylaxis require surgical treatment. Deflux injection may be considered in recipients with low-grade disease. Grade IV and V reflux are best managed with open reconstruction.

3.3. URINE LEAK

Please, see section 1.4. and Figure 12.

3.5. CALCULOUS DISEASE

Occasionally, stones may form in the transplanted kidney or, in some cases, these may be incidentally carried from the donor kidney. Kidney transplant recipients, compared with the general population, are at increased risk for developing urinary calculi and approximately 1%-2% develop a clinically significant stone. Nephrolithiasis can produce secondary hydronephrosis (Figure 29).

3.6. UROTHELIAL TUMOURS

Prolonged immunosuppression following renal transplantation places the transplant recipient at about 100 times the normal risk for developing cancer. The degree of immunosuppression and its duration are both important factors in the development of malignancy. In addition, patients with a significant past exposure to cyclophosphamide have an increased risk for developing of urothelial tumors (Figures 30-31). Although
cyclophosphamide is less commonly used now because of the availability of cyclosporine A, there are many renal transplant patients with a history of cyclophosphamide exposure.

**4. VASCULAR COMPLICATIONS (Figures 32-41)**

Vascular complications occur in approximately 3%-15% of renal transplants and may result in graft loss. Duplex US in the early postoperative period helps to assess vascular complications and to establish a baseline anatomical detail of any variant anatomy for future follow-up. Sometimes Angiography CT is necessary to confirm the diagnoses. Conventional angiography is used very selectively to evaluate suspected vascular complications based on imaging findings seen on other modalities and sometimes is used for treatment.

### 4.1. RENAL ARTERY STENOSIS (Figures 32-37)

Transplant renal artery stenosis (TRAS) is the most common vascular complication in renal transplant patients. The presenting symptom is hypertension that occurs secondary to increased angiotensin secretion. As with the native kidneys, the treatment often involves angioplasty with stent placement.

The cause of RAS has been attributed to various factors, such as the suturing technique, arterial trauma during surgery, infection, atherosclerosis, kinking of the vessel, and rejection. Doppler US findings of RAS include focal areas of colour aliasing, turbulence and spectral broadening and a peak systolic velocity of >200 cm/s.

Contrast angiography remains the standard for diagnosis and management of RAS. A hemodynamically significant RAS is suggested by a >50% luminal narrowing of the renal artery diameter. PTA with or without stent placement is considered as a treatment of choice. Restenosis occurs in 5%-30% cases within 6-8 months.

### 4.2. RENAL ARTERY THROMBOSIS

Renal artery thrombosis (Figure 38) is a rare but very serious complication that occurs in less than 1% of cases. It is seen in the early postoperative period and usually results in loss of the transplant.

It usually results from the surgical technique, such as kinking or torsion of the artery, and dissection of the arterial wall. The other causes include acute or hyperacute rejection, acute tubular necrosis (ATN), and a hypercoagulable state. On US, the most common
finding is the absence of the arterial and venous flow distal to the thrombus and in the intrarenal vessels.

On radionuclide scans of renal artery thrombosis, the graft is seen as a photopenic area and no perfusion is noted within the graft. In the appropriate clinical setting of acute graft dysfunction and US findings of renal artery thrombosis, patients are usually treated immediately with a surgical approach. The other option is catheter-directed thrombolytic therapy.

4.3. SEGMENTAL INFARCTION

Segmental infarction results from thrombosis of the intrarenal arterial branches (Figure 39). On grayscale US imaging, the infarcts may be seen as focal hypoechoic areas that may have echogenic borders. Focal perfusion defects are noted on colour Doppler imaging and radionuclide renal scans.

4.4. RENAL VEIN THROMBOSIS

Renal vein thrombosis (Figure 40) is an uncommon complication occurring in <4% cases. It usually occurs in the early postoperative period with an abrupt onset of graft tenderness, swelling, oliguria, proteinuria, and impaired renal function. The two most important findings are absence of colour and waveform flow in the renal vein and diastolic reversal of flow in the renal artery. On grayscale imaging, the kidney may be enlarged, hypoechoic in appearance and show effacement of the renal sinus. Treatment is usually performed by surgical thrombectomy; however, catheter-directed thrombolysis has been successfully attempted frequently.

4.5. ACQUIRED HYPERCOAGULABLE STATE

Renal transplant recipients manifest a chronic hypercoagulable state contributing to an increased incidence of thromboembolic complications. This situation appears to persist throughout life, but the risk is found to be at its greatest in the first 6 months (Figure 41).

5.- POSTBIOPSY COMPLICATIONS (Figures 42-44)

Percutaneous renal biopsy is an invaluable diagnostic procedure in transplant recipients with diminished renal function to diagnose rejection or other parenchymal processes that
cannot be diagnosed on imaging. The use of real-time ultrasound to guide the biopsy procedure decreases the potential for complications.

Major complications can be defined as those that require intervention or an invasive procedure, such as blood transfusion, embolisation, or surgery. US may demonstrate a focal contusion (Figures 42-43) or cortical hematoma, perinephric hematoma, active extravasation from the biopsy site, focal abscess, clots in the collecting system and bladder, arteriovenous fistula (AVF) (Figure 44) and pseudoaneurysm. Late postbiopsy changes include scar and cortical calcifications. Occasionally, angiography and coiling may be necessary to manage some of these complications.

The main complications of renal transplant, as well as radiological tests indicated for their diagnoses and treatment, are summarized in Figure 45.
**Fig. 4:** Imaging-based classification of renal transplant complications.

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Fig. 5: Chronology classification of renal transplant complications. ATN: Acute Tubular Necrosis; TRAS: Transplant renal artery stenosis; PTLD: post-transplant lymphoproliferative disorder. Certain complications can occur at any time after transplantation, whereas others are related to procedures such as biopsy (for example, hematomas may occur after a biopsy even years after transplant). Illustration inspired from Sharfuddin S. (Ref. 4).

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Fig. 6: Ultrasound appearance of perinephric acute hematoma. The images A and B show septated complex fluid collections (white arrows) around the transplanted kidney (black stars).

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**Fig. 7:** Computed Tomography (CT) without contrast medium. Axial plane (A) and coronal plane (B). Women 60 years old in shock after renal transplant. It shows a heterogeneous and voluminous collection (white arrows) around the transplant (white stars) in relation to perinephric hematoma. Red arrows (picture B) point to free abdominal fluid. The patient was operated on urgently and the surgeon identified the bleeding origin in a polar artery.

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Fig. 8: Figure 8. Lymphocele. Woman 30 years old with renal transplant of seven weeks evolution. Grayscale ultrasound (Images A-B) shows a large anechoic fluid collection (lymphocele, white stars) which is located between the renal transplant and the bladder. It was associated with hydronephrosis (red arrows). Doppler Ultrasound shows normal arteries resistance index (C) and permeability of the arterial anastomosis (D).

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Fig. 9: Figure 9. Lymphocele. The same patient began three days later with lower right extremity edema. Doppler ultrasound was done and deep venous thrombosis was confirmed. Image A shows echogenic content in right common femoral vein (white arrow) and spectral Doppler confirms no vascular flow (Image B). It requires US-guided percutaneous drainage and it has a favourable evolution (Image C). Image D shows the distal extreme of the drainage catheter (white arrow).

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Fig. 10: Lymphocele. Woman 75 years old. Ultrasound (Images A-B) shows a big perigraft fluid collection and it seems to communicate with subcutaneous cellular tissue (blue stars). CT with contrast (Images C-E) confirms these findings. The perigraft fluid collection extends to subcutaneous cellular tissue through interruption of the abdominal wall (blue stars). It had peripheral enhancement with contrast. Urinary leak was ruled out with excretory phase (Image E, red arrow).

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Fig. 11: Seroma. Grayscale ultrasound shows septated complex fluid collections surrounded by a thick capsule. It is localised below the subcutaneous cellular tissue (Image A, blue lines). Colour Doppler US (Image B) shows a poor vascularization. Percutaneous drainage was purulent fluid.

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Fig. 12: Urinoma and urinary leak. Women 68 years old and renal transplant two weeks ago. Grayscale US (Image A) demonstrates an anechoic fluid collection (white star) between the kidney and the bladder (red star). CT shows a collection peripheral enhancement with contrast (Image B, white star). Excretory phase shows a little urinary leak adjacent to the nephrostomy tube (Image C, red arrow). Ureteral reimplantation was done and patient had good clinical evolution.

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**Fig. 13:** Acute tubular necrosis. Man 65 years old with serum creatinine elevation. Colour Doppler US reveals loss of diastolic component (Image A red arrow). Colour Doppler US were done every three days (Images B-D) and resistance index decreased progressively (white arrows).

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Fig. 14: Woman 66 years old with chronic rejection. Gray-scale US shows a small renal transplant, with thin cortex (Image A, white star) and multiple calcifications (Image B red arrows).

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Fig. 15: Kidney post-transplantectomy complications. Women 30 years old, with systemic lupus erythematosus. Acute rejection of renal transplant with transplantectomy and shock. CT without contrast medium shows a voluminous hematoma below the subcutaneous cellular tissue (Images A-B, red arrows). White arrow shows a second hematoma in the transplantectomy site. The superficial hematoma was drained (Image C, drainage catheter). Image D shows the growing of hematoma in the transplantectomy site.

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Fig. 16: Embolisation of renal transplant with chronic rejection. Image A shows permeability of the renal artery (black arrow). The renal artery is anastomosed end-to-side to the external iliac artery (red arrow). Image B shows the coils (black arrow) and the renal artery has been excluded from system circulation.

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**Fig. 17:** Pyelonephritis. Image A. Man 45 years old with renal transplant (three years ago) and dysuria. Gray-scale ultrasound shows hypoechogenic area in the renal parenchymal compatible with pyelonephritis (white arrow). Images B and C correspond to a woman 55 years old with renal transplant, dysuria and fever. It shows increased renal size (Image B white arrow), hydronephrosis (red stars) and thickened urothelium (white arrows).

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**Fig. 18:** Cysts. Images A-B. An early posttransplant US shows incidental cysts present in a cadaveric donor kidney (red arrows). The cyst of image A has a thin septum inside (Bosniak 2).

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Fig. 19: Oncocytoma. Gray-scale and Doppler US. Woman 45 years old and renal transplant four years ago. Annual surveillance ultrasound (Images A-B, red arrows) shows a nodule in the renal lower pole with hyperechogenic central area and periferic vascularization (Image B).

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**Fig. 20:** CT was done to confirm this finding (Image A: basal phase; Image B: arterial phase; Image C: portal phase; Image D: excretory phase). The nodule had enhancement in arterial and portal phases and washed out in excretory phase (solid lesions). US guidance renal biopsy was done and the histopathological finding was oncocytoma. The treatment in this case was thermoablation. The patient is currently asymptomatic and routine US are normal.

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**Fig. 21:** Foreign body. Man 65 years old. First US check after transplant surgery (Image A) exhibits significant acoustic shadowing (red arrow) in the location of the transplant. A conventional radiography shows a foreign body (surgical gauze) (Image B, red arrow). This patient was operated on again.

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Fig. 22: Abscess after foreign body. The same patient began two weeks later with a fever. Grey-scale US shows two heterogeneous collections in parenchyma (Image A, white arrow). Due to the personal antecedents (foreign body), these findings were compatible with abscess. Renal abscess appears as a well-defined hypoechoic nodule, with a hyperechoic central area (Image B, white arrow) within the parenchyma. The study was completed with a contrast US, to define the number and the size of abscesses (Image C, blue lines). It confirms the fluid content. Patient was treated with antibiotics and had good clinical and US evolution (Image D).

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Fig. 23: Hydronephrosis secondary to ureteral stone: Grayscale US shows moderate obstructive hydronephrosis (Image A) and dilated proximal ureter due to ureteral stone (Images B-C, orange arrow). CT without contrast confirms a stone in distal ureter (Image D, orange arrow).

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**Fig. 24:** Hydronephrosis secondary to foreign body. Woman 23 years old. Double J stent was removed one week ago. Grey-scale US shows moderated hydronephrosis of the renal transplant (white star). The distal ureter was dilated due to distal portion of double J stent (Image B, red arrow). Conventional radiography (Image C) and CT without contrast (Image D) confirms this finding (red arrow).

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Fig. 25: Patient 27 years old and renal transplant two months ago. Grayscale US shows hydrenephrosis and dilated proximal ureter (Image A-B, white arrows). 3D volumetric reconstruction of an excretory phase CT (Image C) shows a ureteral stenosis (red arrow).

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Fig. 26: Ureterovesical junction granuloma. Man 65 years old and renal transplant one year ago. Grey-scale ultrasound shows a hyperechoic nodule in ureteral anastomosis (Image A and B, white arrows). This nodule does not present contrast enhancement in CT (Images C and D) and it has peripheral calcifications. Histopathological finding was granuloma. In this case hydronephrosis was not present, but granulomas are other obstructive hydronephrosis cause.

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Fig. 27: Vesicoureteral reflux. Man 27 years old with recurrent tract infection episodes. Grayscale US shows hydroureter (Images A-B, red arrows) and dilated ureter (Image C, red arrow).

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Fig. 28: Voiding cystourethrogram (VCUG) was done to same patient which demonstrated grade V reflux (Images A-B, red arrows). VCUG after surgery was normal (Image C).

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Fig. 29: Calculous disease in renal transplant. Gray-scale ultrasound. Images A and B (same patient) show multiple nephrolithiasis (red arrows) with hydronephrosis secondary (white star). Image C shows lithiasis in medium calicial group (red star) without hydronephrosis. Image D shows bladder stone.

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Fig. 30: Transitional cell cancer. Man 70 years old and renal transplant five years ago. Persistent hematuria. US did not present findings. CT shows a nodule in the proximal ureter with enhancement in arterial and portal phases (Image B and C, red arrows). Excretory phase shows a filling defect (Image D, red arrows). Endoscopic resection was done and histopathological finding was transitional cell cancer.

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**Fig. 31:** Same patient two years later. Gray-scale ultrasound (Image A-B, red arrows) shows a bladder polyp localized in the right lateral and anterior bladder wall. Cystoscopic resection was done and histopathological finding was transitional cell cancer.

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**Fig. 32:** Renal Artery Stenosis. Man 70 years old and renal transplant twelve years ago. Spectral Doppler US shows a very low resistance index (0.50) (Image A) and a very high velocity at the arterial anastomosis (Image B, black arrow), suspicious for stenosis. CT angiography and MIP reconstruction (Image C) and CT angiography and 3D reconstruction (Image D) confirm a calcified atherosclerotic plaque in the origin of renal artery (stenosis>70%)(blacks arrows).

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Fig. 33: Renal Artery Stenosis. Digital subtraction angiography confirms the stenosis of the main renal artery (Image A, black arrow) and stent was placed (Image B, black arrow). One month later, the spectral US shows resistance index normal and velocity at the arterial anastomosis <200 cm/s (Images C and D, red arrows).

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Fig. 34: Woman 65 years old and renal transplant two years ago. Spectral Doppler US shows normal velocity in renal arterial anastomosis (Image A) and very high velocity in other arterial anastomosis (Image B). 3D volumetric reconstruction of arterial phase CT (Image C) confirms double artery in renal transplant (white arrow normal renal artery; red arrow stenosis in the origin of main renal artery).

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**Fig. 35:** Digital subtraction angiography confirms the stenosis in the main artery renal transplant (Image A, red arrow). Balloon Angioplasty was done (Image B, red arrow).

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Fig. 36: Man 50 years old. Grayscale US shows poor vascularization in the renal transplant (Image A). The renal resistance index are diminished (Image B, red arrow) with tardus and parvus waveform. Coronal view CT shows a big calcified atheroma plaque in common iliac artery (Image C, red arrow).

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Fig. 37: Digital subtraction angiography confirms the stenosis in common left iliac artery and origin of the main renal artery (Image A, black arrow) and stent was placed (Image B, black arrow).

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**Fig. 38:** Renal artery thrombosis. Grey-scale US shows poor corticomedullary differentiation in the renal transplant (Image A). Vascularization is not demonstrated in spectral Doppler US (Image B). Image C shows normal radionuclide scan (red arrow) in the same patient three days before. Currently, radionuclide scan (Image D, red arrow) shows no flow in the transplanted kidney.

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**Fig. 39:** Focal segmental infarct in the renal transplant secondary to polar renal artery thrombosis. CT shows perfusion deficit in the renal graft (Images A-B, black arrow).

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**Fig. 40**: Renal vein thrombosis. Man 50 years old. Grey-scale US (Image A) and Spectral Doppler US (Image B) exhibits normal appearance and vascularization of the renal transplant. Two days later, he begins with abrupt abdominal pain and swelling. The new Grey-US (Image C) showed increase in size of renal transplant and poor corticomedullary differentiation. Spectral Doppler US (Image D) shows reversal of the diastolic arterial flow in intrarenal arteries. These findings are characteristic of renal vein thrombosis.

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Fig. 41: Inferior vena cava filter. Woman 35 years old and renal transplant two years ago. Second episode of deep vein thrombosis. Distal external iliac, common femoral and internal saphenous vein were affected (A-B, white arrows). Renal transplant vein was permeable (C). Inferior vena cava filter was placed (Image D, black arrow).

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Fig. 42: Bleeding postbiopsy. Man 50 years old. Renal transplant biopsy was done and he began with hematuria two hours later. Gray-scale US shows hyperechoic content in calyces (Image A, red arrow). CT without contrast was done and confirms these findings (Image B, red arrow).

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**Fig. 43:** Abdominal wall hematoma. Woman 70 years old and renal transplant biopsy two days ago. Abdominal pain and anaemia are her clinical symptoms. Grayscale ultrasound shows a big septated complex fluid collection into abdominal wall (Image A), without vascularization (Image B). Image C shows superficial localization of hematoma (white arrow). Red arrow shows renal transplant with normal vascularization.

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Fig. 44: Intrarenal arteriovenous fistula (AVF). Doppler images after biopsy showed intrarenal pole artery (Images A - orange arrow - and B) with very high velocity with aliasing and low resistance pattern.

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<th>Magnetic Resonance Imaging</th>
<th>Nuclear Medicine Imaging</th>
<th>Digital Subtraction Angiography</th>
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**Fig. 45:** Radiological tests indicated for the diagnosis of complications of renal transplant.

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Conclusion

A wide range of postoperative 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 ultrasound and nuclear imaging, although on other occasions it is necessary to resort to other diagnostic techniques such as the CT Angiogram or arteriography. However, the increasing role of percutaneous management is still being defined. In this presentation, we have reviewed the main complications with different imaging techniques and the main interventional radiologic management of renal transplant dysfunction.
Personal information


References


