IMAGING OF VASCULAR COMPLICATIONS IN RENAL TRANSPLANT
HOSPITAL DE CLINICAS EXPERIENCE
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ABSTRACT

Objectives: 1. Review all results from Doppler ultrasound studies of transplanted kidney at the University Clinics in the period January 2012 - July 2013 and correlate them with other imaging methods in cases with vascular complications. 2. Review the criteria for indication of imaging studies for suspected vascular complications in a renal transplant patient.

Material and methods: A retrospective review of 160 renal Doppler studies was performed. They corresponded to 90 patients from the University Clinics, out of whom 77 had received a kidney transplant, while 13 had received a pancreatic-kidney graft, all of them in the period from January 2012 to August 2013. In those cases with vascular complications, both indication and results of other imaging studies (CT, CT angiography, digital angiography, MR angiography) were reviewed.

Results: In a total of 9 patients (11.6 % of all kidney transplants) vascular complications were detected; in 5 cases, renal artery stenosis was diagnosed by Doppler ultrasound and confirmed by CT angiography or angiography. In 3 patients an arteriovenous fistula appeared after kidney needle biopsy (KNB); in one of them a pseudoaneurysm was also present. In one case renal infarction was detected. In 3 patients with renal artery stenosis angiography with specific endovascular treatment (stent and angioplasty) was performed.

In pancreatic graft cases vascular complications were recorded in 4 patients (30 % of all pancreatic grafts): three venous thromboses and one arterial thrombosis.

Conclusions: In our series, the frequency of vascular complications is similar to that reported in scientific literature. Doppler ultrasound must be the first imaging study; it should be requested in the first 24 hours postoperatively and also later on, if complications are suspected. It is also used to guide interventional procedures. Should vascular complications be found, explorations may be continued with CT angiography, taking care to minimize the potential nephrotoxicity of contrast media. MR angiography without the use of gadolinium may be useful. Angiography is reserved for procedures that are also therapeutic.

Keywords
Kidney transplant
Doppler ultrasound
Computed tomography
INTRODUCTION

Kidney transplant is at present the treatment of choice for patients with chronic renal failure, whether on dialysis or at the predialysis stage. In type I diabetics, a simultaneous pancreatic transplant is associated (pancreatic-kidney transplant). The chief benefit of a transplant is the improvement in quality of life because the patient can discard dialysis and is spared the progression of complications. Although most kidney grafts come from deceased donors, the percentage of relatives acting as living donors keeps increasing. According to data from the national transplant registry for 2008, 88% of donors are deceased donors and the remaining 12%, living donors. (1) In Uruguay, the first kidney transplant was carried out at the University Clinics in 1969, but it was only in 1981 that the kidney transplant program was created; the number of procedures per year has increased since, coming up to the present 140, all of them supported by the FNR (National Resource Fund). The first pancreatic-kidney transplant was done in 2002 at the Nephrology Department of the University Clinics. At present about 10 procedures are carried out yearly.

Kidney graft complications can be either acute or chronic. Acute complications are of diverse origin: parenchymal (rejection, acute tubular necrosis, drug toxicity, infection, etc.), vascular (thrombosis, stenosis, AVF, pseudoaneurysm after KNB, renal infarction), due to fluid collection (hematoma, lymphocele, abscess, urinoma) and urological (urinary tract obstruction, urinary leak, lithiasis). Long-term complications are recurrent nephropathy on the graft, chronic rejection, infection due to immunosuppressants and lymphoproliferative disorder. The first imaging study to be done in a follow-up of renal transplant is Doppler sonography. Since grafts are placed in the iliac fossa, they are rather close to the surface, which allows more penetration of the ultrasound beam and therefore a more precise diagnosis. This technique is widely available, can be done with a portable machine and does not use ionizing radiations or contrast agents. It detects vascular complications and evaluates graft function by assessing echogenicity variations and resistance indexes. In case of vascular complication the available method is CT angiography, though the potential nefrotoxicity of contrast agents should be taken into account. Therefore, the risk/benefit ratio of their use must be jointly evaluated with the medical team and the risks must be minimized by scheduling previous hydration, the use of low doses of more concentrated contrast agent, and scheduling for hemodialysis after the procedure.

Since MR angiography uses gadolinium as contrast agent, the main complication here is systemic nephrogenic fibrosis, an entity producing fibrosis in the long term through an unknown pathological mechanism. It has been demonstrated that one hemodialysis session clears 70% of contrast, while
two sessions eliminate 95% and three sessions, 98%. (2) The European Society for Urogenital Radiology (ESUR) recommends three hemodialysis sessions, amounting to a total of 9 hours, after this study. Sequences that do not require gadolinium have been developed in the last few years, particularly steady-state free precession sequences (SSFP), whose image quality compares to that of MR angiography for the detection of renal artery stenosis. (3) Digital subtraction angiography is the gold standard study for this pathology, since it permits to diagnose morphologically and to treat in the same session. It requires high doses of iodine contrast and ionizing radiations, which explains why its use is limited to cases where endovascular treatment is indicated. This indication must be endorsed by the nephrologist and strictly based on a favorable risk/benefit ratio.

Objectives

1. Review all results of Doppler studies of kidney transplants which were carried out at the Radiology Department of the University Clinics from January 2012 to July 2013 and to relate them to other imaging methods used for the study of vascular complications.

2. Review the criteria for ordering different imaging studies when vascular complications are suspected in a patient with a transplanted kidney.

MATERIAL AND METHODS

All 160 Doppler reports of 90 patients with transplanted kidneys or pancreatic-kidney transplants were reviewed. These patients attended the Imaging Department at the University Clinics during the period January 2012- July 2013 in order to complete the follow-up of their kidney transplant or their pancreatic-kidney graft. The data were provided by the departmental archives. Doppler studies were independently done by the authors. In cases with vascular complications the indications for other studies were reviewed, as well as the results of the imaging studies themselves (CT angiography, digital angiography, MR angiography).

Figure 1: Normal findings in renal graft Doppler
a) Color Doppler with unchanged and symmetrical parenchymal vasculature. b) Spectral Doppler at arcuate level with a low-resistance pattern, systolic and diastolic velocities unchanged.
**Imaging studies**

*Doppler studies* were carried out with different units: Esaote 50, Sonoace X8 Samsung Medison and Ultramark 9 with a 2-4 MHz or 4-7 MHz convex transducer, according to the constitution of the patient. Whenever portable equipment was needed, the Esaote 25 unit was used. The renal graft was evaluated in every case in B mode: size, shape, echogenicity, medullary pyramid index, dilation of excretory cavities and presence of perirenal fluid collections. The medullary-pyramid index is calculated by multiplying length of pyramid by its width, dividing that number by 2, and multiplying the result by cortical thickness. If the end result is over 7.5 it indicates acute rejection.

Vasculature was evaluated using color Doppler, Power angiography and spectral Doppler; permeability of arterial and venous structures was verified and Doppler signal characteristics, such as low/high resistance and acceleration times, were observed. Resistance index (RI) was determined, as well as systodiastolic velocities at different levels (iliac axis, anastomosis, post-anastomosis zone, route, hilum and parenchymal sector). If renal artery stenosis was suspected, reno-iliac ratio was calculated. In some cases renal ultrasound was used to guide to carry out a needle biopsy or to aspirate a fluid collection.

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**Figure 2: Reno-iliac stenosis**

a) Doppler of ilio-renal anastomosis: color aliasing and systolic velocity up to 4m/s. b) Doppler at arcuate level (intraparenchymal location): systolic and diastolic velocities and acceleration ratio remain unchanged, but RI is elevated (0.8).

c) CT angiography, coronal MIP reconstruction: extensive aorto-iliac atheromatosis and stenosis of the left external iliac artery.

d) CT angiography, coronal MIP reconstruction: postanastomotic stenosis of renal artery.
Angiography was done with a 64-row multislice Siemens scanner, giving contrast agent intravenously by means of an injection pump with a flow of 3-4cc/s; a total of 100cc of non-ionic iodine, with a concentration of 320mg/dl, was injected as contrast agent. The arterial phase was achieved using the technique of bolus follow-up, choosing infrarenal aorta as ROI and beginning with a threshold of 100 HU. The portal phase was achieved at 60 seconds in order to detect venous and parenchymal alterations, completing it with a late phase according to the findings. The graft was assessed regarding morphology, size and density; presence of fluid collections was investigated, as well as free fluid in the peritoneal cavity. Uptake of intravenous contrast was evaluated in the different phases (arterial, nephrographic and eliminatory). MPR, MIP and VR reconstructions were performed.

The authors did study reporting independently.
Angiography was carried out at the operating room of the Department of Vascular Surgery, by means of a mobile unit equipped with a C-arm.

**RESULTS**

**Population:**
During the period under examination a total of 90 patients underwent 160 Doppler studies of their transplanted kidney. Where more than one study was done, only the pathologic result was taken into account. There were 44 male patients and 46 female patients, their ages ranging from 19 to 75 years with an average of 45.7 years. Seventy patients received a kidney transplant for the first time, while 7 had a second kidney transplant and 13 received a simultaneous pancreatic-kidney transplant.

![Figure 3: Postoperative torsion of renal pedicle](image)

a) Doppler at intraparenchymal level: great decrease of systolic and diastolic velocities (PSV 21 cm/s and PDV 13 cm/s), “tardus/parvus” pattern with decreased RI (0.35).
b) Doppler at renal hilum: color aliasing and increase of systolic velocity up to 4m/s.
c) CT angiography, coronal MIP reconstruction: abrupt narrowing of interior diameter of renal artery at renal hilum.
d) CT angiography, axial MIP reconstruction: severe stenosis at renal hilum.
The time elapsed between the transplant and the Doppler study ranged from 12 hours to 24 years, with an average of 4 years.

**Normal imaging findings:**

*Doppler:* Regarding *renal graft*, the evaluation was done in B mode and color Doppler. **Figure 1** shows the normal findings. As seen in Doppler studies, arterial flow in the transplanted kidney characteristically evidences low resistance with a continuous diastolic flow. Doppler signal within the parenchyma presents low resistances (less than 0.8) and a quick systolic rise. The venous register at renal vein level has a phasic pattern related to respiration. On the first days of the postoperative period, a little intraperitoneal fluid may be detected. A slight dilation of the excretory cavities may also be seen, arising from various causes: ureteral denervation, edema of the ureterovesical junction and loss of the normal anti-reflux mechanism.

It was possible to identify *pancreatic graft* in the right iliac fossa in every case. The size of the graft, assessed in the antero-posterior direction, ranged from 15 to 25mm (7). It increases in pancreatitis, acute rejection, infection and venous thrombosis. The graft is homogeneously echoic but hypoechoic zones may appear, suggesting infarction, pancreatitis and rejection.

**Figure 4:** Stenosis of ilio-renal anastomosis with parenchymal damage.

a) Color Doppler of ilio-renal anastomosis evidences color aliasing.
b) Doppler of anastomosis with increase of systolic velocity, up to 4 m/s.
c) Spectral Doppler at arcuate level: “tardus/parvus” pattern with increase of the acceleration ratio.
As seen in Doppler, arterial flow within the transplant shows a characteristically low-resistance pattern with continuous diastolic flow. The venous register at renal vein level has a phasic pattern related to respiration.

Computerized tomography: Normal postoperative findings include a scant quantity of free intraperitoneal fluid and slight dilation of excretory cavities.

Complications: Out of the total amount of patients who underwent Doppler studies, only 9 had vascular complications in the graft (11.6% of all kidney transplants). In 5 cases renal artery stenosis was diagnosed by Doppler and confirmed by CT angiography or plain angiography. In 4 of them stenosis was found at the reno-iliac anastomosis; in one of those cases, the iliac axis was also involved. (Fig.2)

The remaining patient presented with stenosis near the renal hilum, brought about by pedicular torsion 72 hours after transplant and 24 hours after reoperation on account of urinoma; both entities had been diagnosed by Doppler and CT angiography and were confirmed by the surgeons. The pedicle was untwisted and the patient did well. (Fig. 3) In 2 out of these 5 cases parenchymal damage was noted at Doppler examination, which showed tardus-parvus waveform pattern. (Fig. 4) Spontaneous resolution was the outcome of 3 arteriovenous fistulae, one of them was associated with a pseudoaneurysm and all were sequels of kidney NB. (Fig. 5)

No acute thrombosis cases, whether arterial or venous, were detected in the kidney. In one case Doppler did not get vessel signal from the renal artery or the intraparenchymal
arteries; this image corresponded to renal infarction in a hypertensive patient on hemodialysis, 7 years after transplant and was not confirmed by other methods.

In 3 patients arteriography with endovascular treatment (stent and angioplasty) was done at the Vascular Surgery Department.

In pancreatic graft cases 4 vascular complications arose, which amounted to 30% of all pancreatic grafts. Out of these 4, 3 were venous thromboses that led to graft loss. They were all diagnosed by Doppler, and 2 of them were confirmed by CT angiography, while the remaining one was confirmed at operation. (Fig; 6)

The other vascular complication was thrombosis of the distal pancreatic artery, which was diagnosed by Doppler and CT angiography; it was treated with anticoagulant agents and had a good outcome. (Fig. 7)

Regarding other non-vascular complications, the diagnoses were: acute rejection, perirenal hematoma, urinary leak, vesicoureteral reflux, renal abscess, tuberculosis (intestinal and pulmonary), lymphocele.

**Indication of studies**

Imaging studies were ordered according to the protocol laid down by the Transplant Team at University Clinics: Doppler of kidney graft within

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**Figure 6: Pancreatic-kidney transplant with hyperglycemia 12 hours after operation, follow-up Doppler study**

a) B mode: Transverse section of head and body of pancreas in RIF, PA diameter of 15mm. The pancreatic artery is visible posteriorly.

b) Spectral Doppler of pancreatic artery: high-resistance Doppler signal with inverted diastolic flow. The portal vein could not be identified.
24 hours after operation, to be repeated if complications or decline of renal function are suspected.

When Doppler detected a vascular complication, the first study to be ordered was CT angiography. In 3 patients therapeutic angiography was performed. If graft rejection was suspected, ultrasound-guided KNB was performed. No patient had a MR scan.

DISCUSSION

Imaging plays an essential role in diagnosing vascular complications of kidney transplant and also contributes to their treatment in some cases. The percentage of vascular complications in our population matches those to be found in scientific literature, both for kidney graft and pancreatic graft. According to Kobayashi (4), vascular complications are frequent and appear in 3-15% of cases of kidney transplant and may cause considerable morbidity, sometimes leading to graft failure, which is why an early diagnosis is important.

The first study to be performed is the ultrasound scan. The Doppler technique offers valuable information about the vessels and possible vascular complications in the grafted kidney. It is also a very sensitive method to detect urinary tract obstruction and perirrenal fluid. Due to the superficial situation of the kidney and to the absence of interfering intestinal gas, it is possible to visualize the graft in practically every patient. (5)

The indicators of acute renal rejection are known: progressive kidney enlargement, increase of RI above 0.8, increase of the medullary-pyramid index. The latter one, however, is not specific. (4, 5) An isolated RI increase may indicate rejection, acute tubular necrosis, drug toxicity, renal vein thrombosis, kidney compression, pyelonephritis and obstruction (4, 5) A KNB may determine etiology. Renal artery stenosis of hemodynamic significance is suspected on Doppler on account of indirect signs like decrease of parenchymal vasculature and tardus-parvus waveform, and also on account of direct signs like aliasing, acceleration of systolic velocities at the zone of anastomosis (more than 250cm/s), and increase of the renolilac index (above 3.5). (4) In the case of stenosis caused by rotation or kinking and resulting in occlusion, thrombosis of the renal artery or the renal vein treatment is urgent, a surgical revision is mandatory and no other diagnostic examination should be performed.

Diagnosing thrombosis is straightforward: echogenic material present within the vascular lumen, absence of both color Doppler signal and Doppler image. Renal vein thrombosis may be suspected when RI is increased and diastolic flow is inverted. (4)

Stenosis due to intimal hyperplasia or atherosclerosis and stenosis due to technical failure do not usually generate immediate risk to graft vitality. A more detailed diagnosis is required, with particulars about topography, stenosis degree, characteristics of the plaque and of the vascular bed that acts as its foundation.

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Doppler is highly sensitive for the detection of pseudoaneurysm, which is evidenced as a peri-anastomotic fluid collection with intraluminal flow. In color Doppler the yin-yang sign is visualized, while Doppler shows a diagnostic back and forth waveform. If size and clinical picture make surgical revision urgent, no other imaging is necessary.

An arteriovenous fistula, generally a sequel of KNB, is diagnosed by the presence of high-velocity flow in the parenchyma, decrease of arterial resistance and, in severe cases, “arterialization” of the renal vein. Evaluation of normal pancreas can be difficult since the absence of capsule makes for blurry borders and if the liver is not adjacent to it, pancreatic echogenicity is hard to assess. Duodenal gas can also interfere with visualization of pancreas or hide it completely.

The presence of peripancreatic fluid, a normal finding on the first postoperative days, can facilitate pancreas visualization, by providing an acoustical window. (6) When thrombosis of the pancreatic vessels (artery or vein) is suspected, diagnosis should be attempted first with Doppler. Parameters should be optimized for slow flow, however, since otherwise one might arrive to a false positive diagnosis of thrombosis. The findings would be: absence of portal flow, increase of RI that may invert diastolic flow. (6) In these cases surgical treatment is urgent and no other studies are required.

In case of acute pancreatic rejection, ultrasound findings might be unspecific and therefore, correlation with the clinical picture and serum markers is basic. On reviewing all this, treatment guidelines emerge, as well as the need for other imaging studies like CT, MR and ultrasound-guided needle biopsy. Since

Figure 7: Pancreatic-kidney transplant with hyperglycemia during the first postoperative week, follow-up Doppler study: a) B mode: intraluminal echogenic material (arrow) within both splenic artery and distal part of mesenteric artery. b) Color Doppler: no vasculature at that level (arrow).
pancreas, unlike kidney, has no capsule, increase of RI is unspecific. (6) Enlargement of pancreas and focal hypoechoic areas have been described, but those signs are unspecific. (7)

**Computerized tomography**
CT is indicated in patients with vascular complications, in order to complete data obtained by ultrasound. (12)
Intravenous administration of contrast agents is important to evaluate graft perfusion. As already mentioned above, nephrotoxicity risks must be minimized by adequate previous hydration, use of high-concentration contrast agents and smaller volumes of contrast. CT angiography can detect stenotic zones and define their characteristics, as well as evaluate both pseudoaneurysms and arteriovenous fistulae. CT performs better than ultrasound when assessing fluid collections and urinary leaks, as well as other causes of abdominal pain. It can also serve to guide drainage of fluid collections.

**Interventionism**
Ultrasound is the main method of guidance in interventionist procedures (needle biopsy, aspiration and drainage of fluid collections) because it permits real-time follow-up of the procedure in multiple planes. Due to the superficial situation of these intraperitoneal transplanted organs it does not have important technical limitations. Needle biopsy of the graft is indicated if rejection is suspected. Needle aspiration and, eventually, drainage of fluid collections are important to determine their nature. It can be guided by ultrasound and/or CT.
Nephrostomy may be indicated in cases of urinary tract obstruction. Its performance is guided by ultrasound and radioscopy.

**Digital angiography**
It is the gold standard of diagnostic studies for vascular complications and their therapy. In the case of renal artery stenosis, the treatment of choice is percutaneous transluminal angioplasty, with a success rate ranging from 85 to 93%. Complications of this procedure are: arterial dissection, rupture and thrombosis, the latter of which occurs in less than 4% of cases. (4)
Re-stenosis appears in 5-30% of cases and can be treated with stent placement. Surgery is reserved for patients where endovascular treatment failed or was impossible. As mentioned above, endovascular treatment is also recommended for AVF or pseudoaneurysm.

**Magnetic resonance**
MR and MR angiography are playing an increasingly important role in vascular complications and graft rejection, since they are highly sensitive and specific. At the present moment, the development of new sequences for MR without use of gadolinium is playing a major role in the diagnosis of vascular complications, as mentioned in the Introduction.

**CONCLUSIONS**
In our series the rate of vascular complications is similar to that reported in scientific literature.

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Doppler ultrasound should be the first imaging study to perform, it is requested within the first 24 hours of the postoperative period and later, whenever complications are suspected. It also serves to guide interventionist procedures. Should vascular complications be confirmed, imaging study will go on to CT angiography, with mandatory minimization of nephrotoxicity due to contrast agents. MR angiography without the use of gadolinium may be of use. Angiography is reserved for procedures that are also therapeutic. In order to interpret imaging results it is of fundamental importance to know the surgical technique, and also to be familiar with the aspect of normal grafts and with postoperative complications.

APPENDIX: Kidney transplant, an update.

Most kidney grafts come from deceased donors but there is an increasing percentage of relatives acting as living donors. According to data of the national graft registry of 2008, 88% of donors were deceased and 12%, living donors. (1) In our country the annual number of kidney transplants is approximately 140. They are financed through the FNR (National Fund of Resources). The Nephrology Department at the University Clinics acts as one of the transplant centers.

Surgical technique

The grafted kidney is placed in the right iliac fossa if it is the first graft or in the left iliac fossa if it is the second kidney graft or a PKT. The graft is also placed on the left if the right iliac axis of the recipient is altered.

As far as arterial anastomoses are concerned, they will depend on the type of donor. Should it be a deceased donor with a single pedicle, the anastomosis will be an end-to-side anastomosis with an aortic patch on the external iliac artery. If there are multiple pedicles (a variant present in up to 20% of cases), a side-to-side anastomosis may be performed, along with the fashioning of a common ostium. In the case of living donors the use of an aortic patch is impossible. (4)

Venous anastomosis, on the other hand, is made end-to-side to the external iliac vein; if multiple renal veins exist, ligatures will be used since collateral networks are always available.

The ureter of the grafted kidney is anastomosed by dissecting the right bladder wall and anchoring it there; in this uretero-neo-cistostomy the ureter is tunneled through the bladder wall in order to avoid reflux. Double J catheters have been in use in this country since 2012, due to high incidence of urologic complications (urinary leaks).

A pancreatic graft is placed in the right iliac fossa and both the splenic artery and the superior mesenteric artery of the donor are anastomosed to the common iliac or the external iliac of the recipient. Venous anastomosis is established between the portal vein of the donor and the common iliac vein or the external iliac of the recipient. Exocrine drainage of pancreas takes place through the donor duodenum which is joined to a
loop of the small intestine of the recipient. Advances in surgical technique, postoperative management and immunosuppressant therapy have brought about a decrease in graft complications and in the failure rate of grafts. (5)

**Complications**

Vascular complications occur in 3 to 15% of renal transplants and cause considerable morbidity. They are the main cause of graft failure in the first year. (4)

Renal artery stenosis is clinically evidenced by arterial hypertension refractory to every treatment and/or deterioration of renal function. The causes are multiple: poor suture technique, arterial trauma during transplant, arterial kinking, atherosclerosis of recipient artery and cytomegalovirus infection. Stenosis can be localized proximally to the anastomosis (proximal iliac pathology), at the anastomosis itself (the most frequent instance) or distally to the anastomosis.

Arterial or venous thrombosis is a rare complication (0.5 to 6.2% of cases) but it causes graft failure. The causes of arterial thrombosis are torsion, kinking or dissection. Venous thrombosis may be the result of poor surgical technique, external compression or extension of an iliofemoral DVT.

Complications deriving from a kidney needle biopsy (KNB) range from 0.06 to 18%. (4) They depend on many factors: ultrasound guidance, needle caliber and imaging follow-up. Such complications are: arteriovenous fistula (AVF), pseudoaneurysm and perirenal hematoma. The first two are the most frequent ones and are easily detected by color Doppler; 70% of them resolve spontaneously but the remaining 30% are symptomatic (persistent hematuria, graft dysfunction). Enlargement of pseudoaneurysm can lead to its rupture. If the diameter of either pseudoaneurysm or AVF is greater than 2 cm, endovascular therapy is recommended. Extrarenal pseudoaneurysms appear very rarely at the site of anastomosis as a consequence of poor surgical technique or infection.

Acute rejection, which occurs in up to 40% of transplants, is evidenced by fever, pain at the graft site, oliguria and proteinuria. An increase of the resistance index, surpassing 0.8, is very suggestive of acute rejection, but it is not specific. KNB is required to confirm the clinical diagnosis. Chronic rejection is a cause of graft failure and is evidenced by cortical thinning and slight pyelocaliceal dilation.

Complications of pancreatic grafts are frequent: 60% of pancreatic grafts undergo rejection episodes. There may be other complications like pancreatitis, peripancreatic fluid collections, pancreatic fistula, vascular thrombosis, etc. (6) Thrombosis, whether arterial or venous, is a severe complication that appears early. Some circumstances have been thought to have an influence on thrombosis onset: duration of ischemia, vascular kinking and slow flow. The main cause of pancreatic graft failure is rejection, either acute or chronic (40%). (7) Since pancreatic graft failure is generally synchronous with kidney graft failure (8), an increase of
creatininemia and BUN are usually taken as indirect proof of pancreas failure. In difficult cases, one can confirm the diagnosis by means of KNB. Should doubts persist, ultrasound – or CT-guided pancreatic biopsy can be done, although this procedure implies some risk. (9)

BIBLIOGRAFIA