Radiological evaluation of potential renal graft recipients

Poster No.: C-0335
Congress: ECR 2011
Type: Educational Exhibit
Authors: M. C. Sebastia, M. Musquera, R. Salvador Tarrason, L. Bunesc Villalba, B. Paño Brufau, C. Nicolau; barcelona/ES
Keywords: Arteries / Aorta, Vascular, Abdomen, CT-Angiography, Conventional radiography, CT, Computer Applications-3D, Computer Applications-Detection, diagnosis, Observer performance, Arteriosclerosis, Transplantation, Calcifications / Calculi
DOI: 10.1594/ecr2011/C-0335

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Learning objectives

**Fig.**: Title

**References**: Radiological department, Centre de diagnòstic per la imatge, Hospital Clinic de Barcelona - barcelona/ES
- To depict radiological techniques and indications for evaluation of lower urinary tract and vascular map in renal graft recipients.

- To discuss the optimal multidetector computed tomography (MDCT) technique and radiological findings that must be reported for presurgical evaluation of potential kidney transplant recipients.

- To review radiological tests that can predict cardiovascular complications in patients with end-stage renal disease
Background

In the last 20 years important advances have taken place in renal transplantation. All these advances allow us to expand the pool of renal donors and renal recipients. Unfortunately, globally speaking there is a shortage of grafts compared with the increasing number of recipients on the waiting list.

Recipients with previous contraindications like elderly, diabetic and high cardiovascular risk patients and high-risk surgical patients with severe hypertension, renal failure secondary to urologic malformations or diversions or with difficult vascular conditions, now, have safe access to transplantation.

Because of the increasing complexity of these marginal recipients, radiological evaluation is becoming more and more important.

1. Some patients will require urinary tract radiological evaluation.
2. An aortoiliac vascular map will be necessary in most patients.
3. Tests predicting probability of cardiovascular complications must be performed on most recipients.

In this exhibit we will explain the radiological approach for these three topics. There is only one article, published this year in Radiographics, evaluating potential kidney transplant recipients from a radiological approach (1).
Imaging findings OR Procedure details

**EVALUATION OF LOWER URINARY TRACT:**

Pretransplant urinary tract evaluation should be limited to patients in which we need the following assessed: on page

- **Bladder capacity** (specially if the patient has been on dialysis for a long period time)
- **Possible bladder dysfunction**
- **Suspected urinary reflux**

In these cases a cystogram, ultrasound and contrast enhanced ultrasound, CT cystography, cystoscopy and functional tests can be performed.

- **Urinary diversion**, in which case a conduitography must be performed

In our hospital we perform voiding cystourethrogram in these patients on page because with this test alone we can evaluate several points: **ureteral reflux, bladder capacity, bladder diseases, postvoid residual urine volume and urethral problems.**

**EVALUATION OF AORTOILIAC VASCULAR MAP**

We perform an **abdominal X-ray** in all patients to rule out aortoiliac vascular calcifications, but in patients over 40, with cardiovascular risk factors with diabetes mellitus or awaiting for a second or third renal transplant, a more precise evaluation is required.

Kidney grafts are usually located in the pelvis with arterial and vein anastomoses to the external iliac vascular system. Knowledge of the condition of iliac vascular system is necessary in order to discover **calcifications, aneurysms and stenosis** on page in this sector that can impede or change kidney graft location.

These findings can be depicted with:
- An unenhanced CT to see vascular calcifications and Doppler ultrasound to see iliac vascular system.

- Unenhanced CT plus CO angiography to avoid intravenous contrast administration in preemptive patients.

- MRI-angiography plus unenhanced CT to see calcifications, not visible with MRI.

Gadolinium administration in patients with end stage renal disease is controversial due to the well known complication of nephrogenic systemic fibrosis. Although in the recently published article by Dr Heinz-Peer the real prevalence of NSF in end-stage disease is lower than in previously published literature (2) because the use the NSF mechanism is not totally understood, administration of gadolinium in these patients is not recommended.

**MDCT ASSESSMENT IN POTENTIAL RENAL RECIPIENTS**

Multidetector CT is the most efficient test to assess vascular calcifications and associated diseases in potential renal recipients (3).

Contrast-medium induced nephrotoxicity (CIN) is also the drawback of the universal use of contrast-enhanced CT in performing aortoiliac vascular map.

Although, the article by Dr. Katzberg recently published in Radiology minimizes the risk of CIN associated with intravenous contrast administration performed in CT even in patients with end stage renal disease (4)

In our hospital abdominal X-rays is performed in all recipient candidates.

If the patient is over 40, is diabetic, has cardiovascular risk factors, is the second or third renal transplant or has calcifications in the abdominal X-ray MDCT is performed.

If the patient is on dialysis contrast-enhanced MDCT is performed, if the patient is preemptive an unenhanced CT is performed, if no vascular calcification is depicted we stop here, if there are vascular calcifications we perform contrast enhanced CT after CIN profilaxis. See scheme.

This MDCT is repeated every two years if vascular disease is detected or every 5 years if no findings have been seen in the first MDCT.
Our **MDCT study protocol** of potential renal recipients consists of an unenhanced and an arterial phase:

- **The unenhanced phase** is used to detect calcifications and serves as a baseline for enhancement of any selected lesion.

- **The arterial phase** depicts the aortoiliac map.

- **A venous phase** is performed only if there is the suspicion of abdominal venous disease.

We have been successfully using a **low-dose protocol of 100kVp** in patients weighing less than 85 Kg with an average effective dose decrease of 30%.

With a **dual energy MDCT** on page we only need to perform the CT in the arterial phase. From this source we can later obtain a virtual unenhanced CT an iodum map and we can also subtract calcifications.

According to the experience at our institution:

- An arterial segment of 3cm or longer, free of parietal calcifications, is necessary to achieve a correct arterial anastomosis because a shorter length of healthy artery hinders Satinsky clamp vascular clamping.

- In more advanced atherosclerotic patients we need at least 2 gaps of 1cm free of calcifications to put proximal and distal clamps and another gap in between to perform arterial anastomosis.

- The surgeons also need to know if calcified plaques are concentric or non concentric because if one part of the wall is free of calcifications it can be used to anastomose the graft artery in extreme cases.

If we suspect abdominal venous disease we must add a venous phase in our MDCT protocol. Chronic thrombosis can be depicted in the unenhanced or arterial phase because the thrombosed vein is small and calcified, but venous phase MDCT is mandatory to depict acute venous thrombus and partial thrombosis, in these cases, as you can see in this example, the diameter of the renal vein does not shrink.

We always perform a **curved plane** following iliac artery system in the coronal and sagittal plane, these reconstructions are extremely useful to depict non calcified atherosclerotic
plaques, we then transform these curved planes into thin-MIPs (from 3 to 10mm of thickness) to avoid drawing mistakes of the curved plane and to see the iliac artery system with volume. See examples on page .

Although the volume rendering reconstruction gallery is infinite our surgeons like the MIP reconstructions and the volume rendered MIP-like reconstructions the most. For them, these are the most understandable reconstructions and the possibility of turning them in any direction, avoids problems due to the presence of dense material in the colon, consistent with Lanthanum phosphate binder. See examples. on page

Some centers only perform unenhanced CT in preemptive patients with diffuse calcifications. From our point of view this study is insufficient because iliac stenosis are not depicted. In this example we can see serious bilateral stenosis in non calcified areas, not seen in unenhanced CT. See example on page .

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**Recipients with malformations** are always studied with MDCT in the arterial and venous phases to rule out vascular malformations and depict space in the iliac fossae. See example on page .

An increased incidence of renal tumors (specially papillary carcinoma) has been reported in patients with end-stage-renal-disease and receiving dialysis. Although renal tumors are best depicted in the nephrographic phase, the enhancement presented in the arterial phase would be sufficient, as Dr. Takebayashi claims (5), see examples. on page

**DIFFICULT VASCULAR CONDITIONS**

In difficult vascular conditions we have more complicated surgical options for transplantation like:

- Vascular endarterectomy or stent
- Orthotopic transplantation
- Previous or simultaneous aortoiliac by-pass or aneurysm repair and renal transplant.

In **orthotopic transplantation** the splenic artery is anastomosed to the graft renal artery and the recipient renal vein to the graft renal vein. Pyelopyelic anastomosis is used for the urinary tract.

The splenic artery is routinely studied in MDCT for renal recipients to rule out calcifications and stenosis. Patency and size of the left renal vein must also be depicted. See images on page .

**Simultaneous aortoiliac by-pass and renal transplant surgery** is being done increasingly, above all in living renal donor transplantation that allows non emergency surgery with the option of planning multidisciplinary surgery. Artificial or fresh prosthesis can be used. See images. on page

To perform these types of surgery **information about suprarenal and infrarenal abdominal aorta** must be reported, for proximal aortoiliac bypass anastomosis and the state of femoral arteries and in most cases the **state of inferior extremities vascular map** must be depicted for distal bypass anastomosis. See examples on page . In our hospital when universal calcification of aortoiliac vascular system is depicted in the unenhanced phase we included lower extremities study in our MDCT protocol.

**HIGH CARDIOVASCULAR RISK (CVR) RECIPIENTS**

In high cardiovascular risk recipients mortality from cardiovascular events in the waiting list or after transplant with a normal functioning renal graft is the biggest handicap. We need to study these patients to depict the presence of current cardiovascular problems and perform other tests to predict cardiovascular problems in the future. See cardiovascular risk factors and tests. on page

Several radiological and laboratory findings have been published in the recent literature for prediction of cardiovascular risk on page . The most frequently used are carotid Doppler ultrasound and arterial stiffness evaluation.

If we perform a toracoabdominal MDCT with cardiac study all of the following findings can be depicted:

- descendent thoracic aorta calcification
- left ventricular morphology
- cardiac valve calcification
- coronary calcification
- coronary stenosis
- abdominal aortic calcifications

In the future, if a score based on all these findings is elaborated, MDCT could be a one stop-shop test for cardiovascular risk prediction on page (6).
Conclusion

MDCT IS THE MOST EFFICIENT TEST TO ASSESS A VASCULAR MAP AND ASSOCIATED DISEASES IN POTENTIAL RENAL GRAFT RECIPIENTS. IN THE FUTURE MDCT COULD BE A ONE STOP-SHOP TEST FOR CARDIOVASCULAR RISK PREDICTION
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