

Doppler sonography evaluation after renal transplantation: what can go wrong?

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LEARNING OBJECTIVES

- To illustrate the most frequent Doppler sonography findings after kidney transplantation: What's normal and pathologic.
- To explain technical aspects of Doppler evaluation: "tips and tricks" to detect early posttransplantation renal allograft perfusion (venous and arterial) failure.
- To present a comprehensive pictorial review of the most frequent vascular and non-vascular complications, after kidney transplantation.

Fig. 1

References: L. Andrade; Radiology, Coimbra, PORTUGAL

Background

BACKGROUND

- Recently there was a large increase in the number of kidney transplants performed worldwide.
- For this reason, Doppler studies, are also increasingly being ordered by surgeons and physicians.
- The most frequent complications after renal transplantation can be identified using Doppler sonography; both vascular and non-vascular complications can be early detected, with this non-invasive technique.

Fig. 2

References: L. Andrade; Radiology, Coimbra, PORTUGAL

Imaging findings OR Procedure details

IMAGING FINDINGS

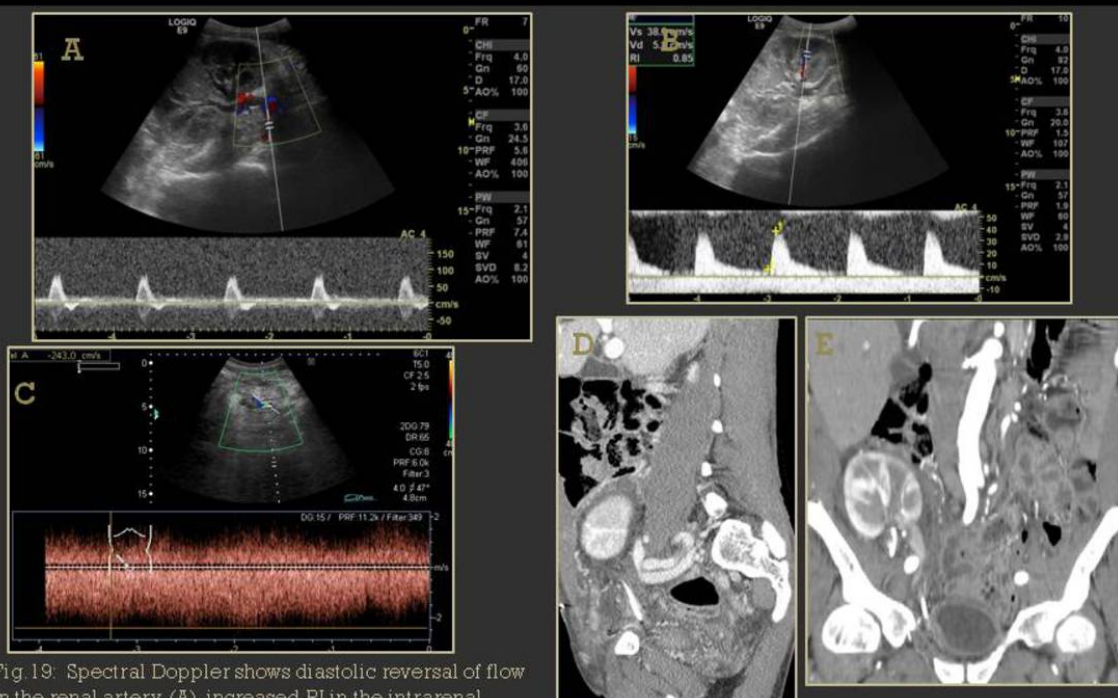


Fig. 19: Spectral Doppler shows diastolic reversal of flow in the renal artery (A), increased RI in the intrarenal arteries (B) and increased velocity in the vein (C). CT images show stenosis of renal vein by extrinsic compression caused by external iliac artery (D and E). Renal vein stenosis had most likely been due to the renal vein being stretched and flattened at the point where it crossed the prominent external iliac artery. This had resulted in a low flow situation with subsequent thrombus formation.

Fig. 36

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

ANATOMY AND TECHNIQUE

Anatomy and Technique

- The transplant kidney is usually placed extraperitoneally in the right or left iliac fossa
- The vascular anastomosis is usually made with the external iliac vessels. In our hospital vascular anastomosis is made with common iliac vessels
- In cadaveric transplants, the donor renal artery is obtained along with a small patch of the aorta termed as "Carrel patch" and is anastomosed end-to-side with the recipient external iliac artery/ common 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 or with common iliac artery

Fig. 3

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

ANATOMY AND TECHNIQUE

Anatomy and Technique

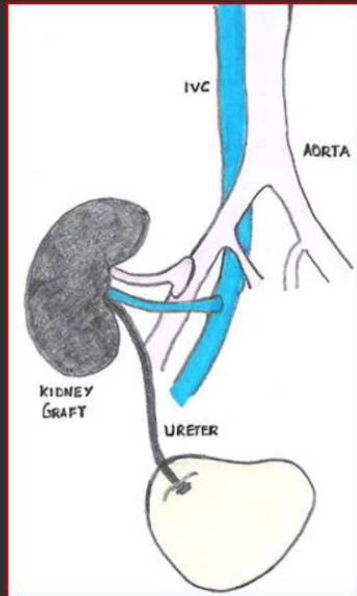


Fig 1: Schematic representation

- For the venous anastomosis, an end-to-side anastomosis is made to the external iliac vein
- Ureteral anastomosis is usually made by creating a new ureterocystostomy
- Ureter length is kept short in order to avoid ischaemia

Fig. 4

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

ULTRASOUND EVALUATION

B Mode examination

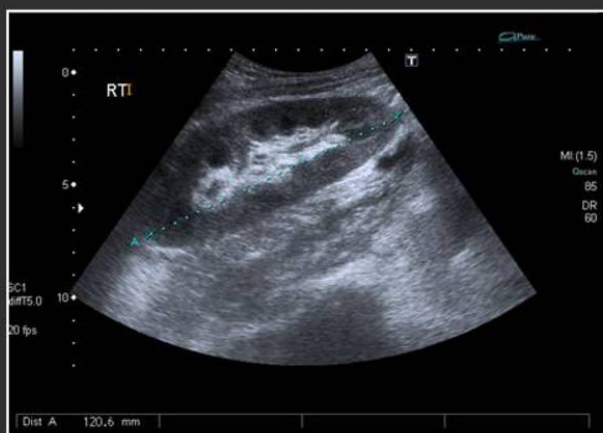


Fig 2: Renal graft has the same ultrasound appearances as the healthy native kidney, but more detail is apparent because the transplant is more superficial so that higher-frequency transducers can be used

Assessment of:

- Renal size
- Echogenicity and corticomedullary differentiation
- Perinephric fluid collections (size or variation in fluid quantity, ensure correct drainage catheter placement)
- Hydronephrosis
- Stones
- Masses

Fig. 5

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Color Doppler

- Iliac and renal vessels are checked for patency and flow direction.
- Imaging of normal anastomoses of the renal artery and vein to the iliac vessels.

Ultrasound Evaluation – Doppler

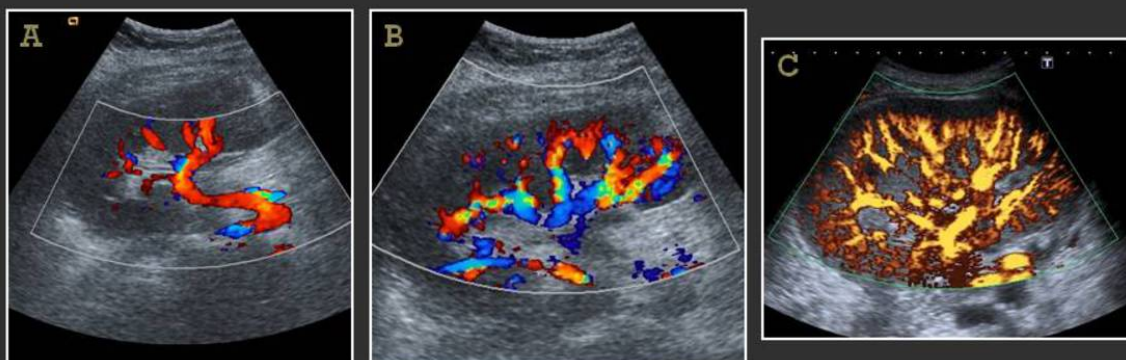


Fig 3: Vascular supply and drainage are best seen using color Doppler. The poles may not show as many small vessels as the midportion, because the blood flows at right angles to the Doppler beam. By tilting (heeling and toeing) the transducer, this problem can be mitigated but not always eliminated, hence in practice, slight doubt may remain about polar flow. (A and B).

The intrarenal vascular anatomy is often more completely shown on power Doppler, that also has less angle dependence so that flow at right angles to the beam, notably that at the renal poles, is less likely to be missed (C).

Fig. 6

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Spectral Doppler

- Evaluation of arterial and venous (iliac and renal) waveforms
- Renal artery (low resistance type); peak systolic velocity (PSV) < 180-200cm/sec
- Intraparenchymatous arteries : $IR \leq 0,7$

Ultrasound Evaluation – Doppler

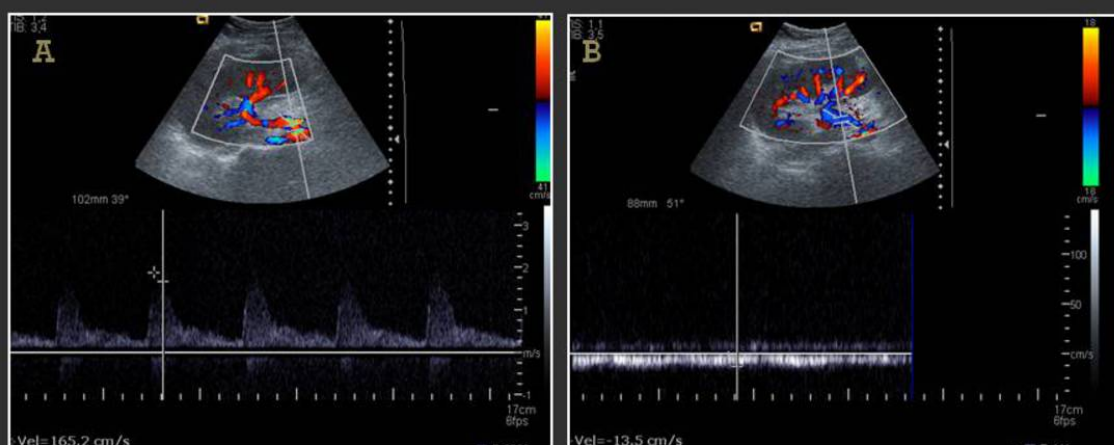


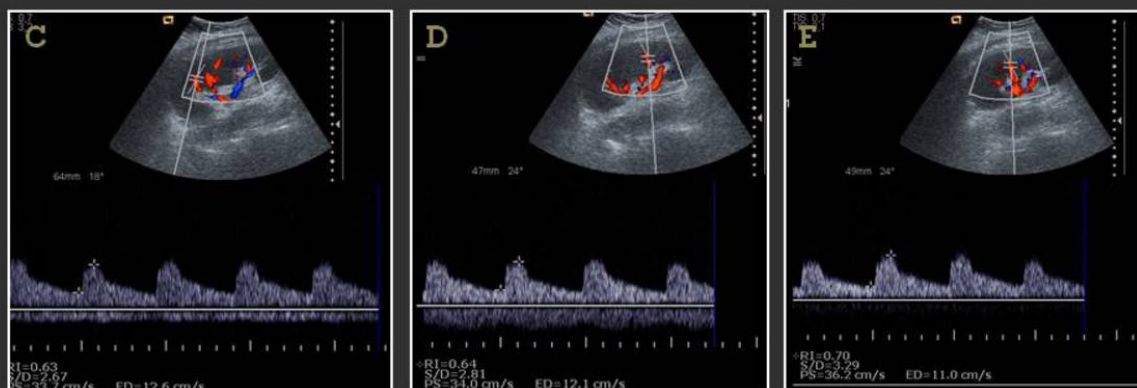
Fig 4: Spectral Doppler findings: normal low resistance flow within renal artery (A) and normal continuous flow within renal vein (B).

Fig. 7

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Ultrasound Evaluation – Doppler



Spectral-Doppler shows normal intraparenchymatous arteries with normal RI (0,6-0,72) and a expected wave morphology typical of intraparenchymatous arteries (low resistance = low pulsatile) (C, D and E).

Ways to improve the Doppler signal:

- Reducing the sample box. The smaller the sample box is, the less the computer works.
- Small angle when measuring flow speed (it should be between 30-60°).

Fig. 8

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

COMPLICATIONS

1. PERINEPHRIC FLUID COLLECTIONS

- Common in the early posttransplant period
- Include hematomas, seromas, urinomas, lymphoceles and abscesses
- US features are nonspecific in differentiating various types of collection (varying according to their composition and location)
- Definitive diagnosis is only made after analysis of the aspirated fluid

Fig. 9

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

1.1. Hematomas

- Very common in the early posttransplant period and should be regarded as a normal sequelae to surgery.
- The incidence of significant posttransplant hematomas is around 4-8%.
- Small perinephric fluid collections, crescent-shaped, in the immediate postoperative period are most often hematomas or seromas.
- The size, location and growth determine the significance of these collections. Since an increase in size may indicate the need for surgery, should be documented the size of these collections on the baseline scans.

Fig. 10

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

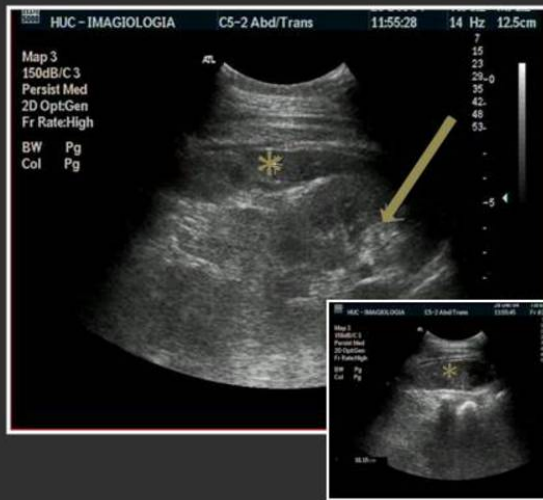


Fig 5: An US of the kidney shows a crescentic complex fluid collection (*) around the kidney (arrow).



Fig 6: Status after biopsy of the kidney graft. The echogenic material surrounding the kidney is compatible with a hematoma (*).

Fig. 11

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

1.2. Abscess

- Heterogeneous perinephric fluid collections in the early postoperative period, associated with clinical signs of infection are more likely to be an abscess.
- US is not specific in differentiating the abscess from other collections; presence of air is suggestive of an abscess.
- Can result from infection of any previous perinephric fluid collection.

Fig. 12

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

1.3. Urinoma

- Relatively rare complication: incidence of urine leak is about 1-5%
- Early postoperative period, in first 2 weeks after transplantation
- Urinomas are extraperitoneal collections usually between the kidney and the bladder
- They cause immediate postoperative pain, swelling and leakage through the surgical suture
- Most leaks occur at the distal ureter or at ureterovesical anastomosis and are secondary to surgical technique and /or distal necrosis of the ureter
- On US urinomas are seen as anechoic fluid collections that may rapidly increase in size; internal septa are uncommon
- US or CT - guided drainage of these collections may show a high creatinine level and provide a more definitive diagnosis

Fig. 13

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

1.4. Lymphocele

- Generally present 4-8 weeks after transplantation
- Reported incidence of up to 18% cases of transplants
- The cause is related to the disruption of normal lymphatic channels during surgery
- Most are discovered incidentally because they are asymptomatic, but when large they may cause mass effect and compression of the ureter or other adjacent structures
- On US lymphoceles are mostly often anechoic
- The lymphocele can be treated with percutaneous or surgical drainage

Fig. 14

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

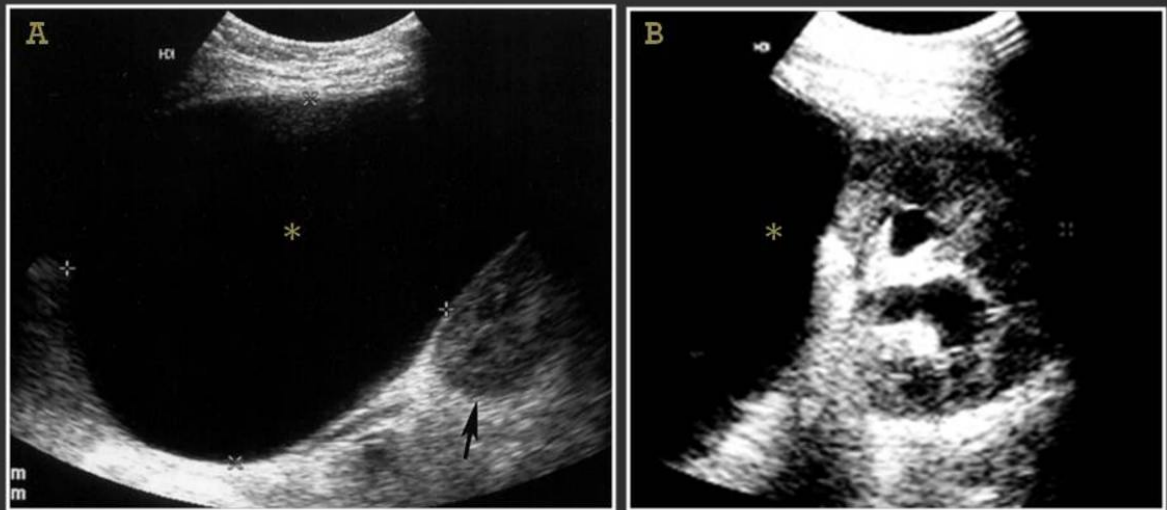


Fig 7: Lymphocele (*) adjacent to renal graft (black arrow). The collection is mostly anechoic and shows no septations (A).

A large lymphocele (*) is seen as a relatively anechoic fluid collection compressing the kidney, ureter and bladder with mild hydronephrosis (B).

Fig. 15

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

COMPLICATIONS

2. VASCULAR COMPLICATIONS

- Relatively uncommon complications seen in less than 10% cases of renal transplants
- Doppler US remains the initial investigation of choice in evaluating the early vascular complications
- Conventional angiography remains the gold standard for the diagnosis and management of the vascular complications

Fig. 16

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.1. Renal Artery Stenosis (RAS)

Complications – Vascular Complications

- The most common vascular complication in renal transplants, affecting up to 10% cases
- Generally occurs within the first 3 months, but it may develop early or late after transplantation
- Responsible for approximately 1-5% cases of posttransplant hypertension and should be suspected in severe hypertension refractory to medical treatment
- It can occur near the anastomotic site, at the distal donor artery, or at the recipient artery, but the most common are stenoses of the anastomotic site and proximal renal artery
- End-to-end anastomosis is shown to have a 3-fold increased risk of stenosis as compared with the end-to-side anastomosis
- The cause has been attributed to various factors, such as sutural technique, arterial trauma, during surgery, infection, atherosclerosis, kinking of the vessel, and rejection

Fig. 17

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

- Doppler US findings:

- Stenotic segment:

- Focal area of color aliasing, turbulence and spectral broadening
- Peak systolic velocity > 200cm/sec
- Velocity ratio of stenotic to prestenotic segment of greater than 2:1 (the peak velocity in the transplant artery is double that in the iliac)
- Doppler frequency shift of greater than 7,5kHz when a 3-MHz transducer is used

- Postenotic segment:

- Delayed systolic upstroke (tardus-parvus waveform) distal to stenosis and in the intrarenal arcuate arteries
- Tardus-parvus waveform: delayed upstroke in systole (prolonged acceleration time [$>0,07\text{sec}$]), rounding of the systolic peak and obliteration of the early systolic notch.
- Resistive index < 0,56

Fig. 18

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

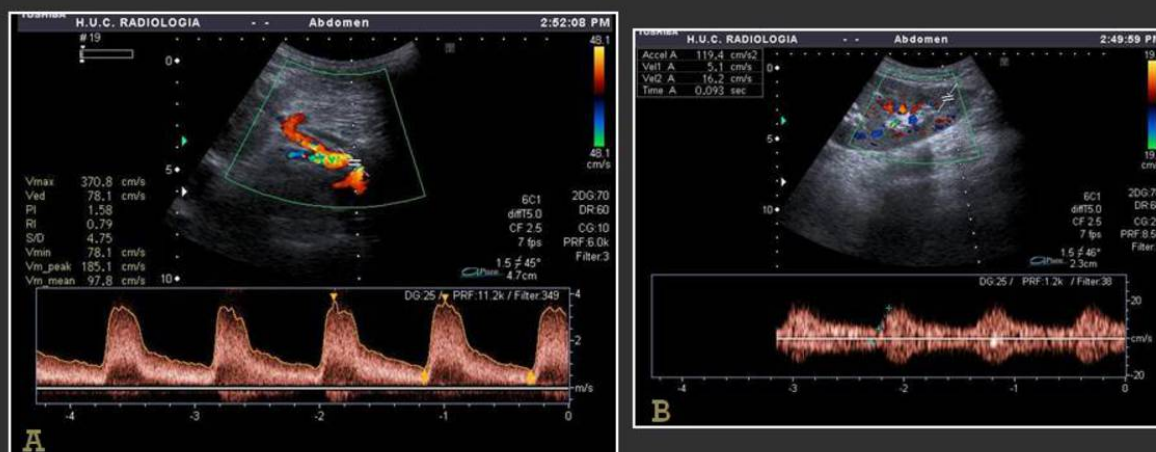


Fig 8: Color Doppler shows a focal area of color aliasing and turbulence in the arterial anastomotic region. Spectral analysis demonstrates a peak systolic velocity of 370cm/sec (A), and a tardus-parvus waveform in the intrarenal arteries (B).

These findings are suggestive of renal artery stenosis in the region of anastomosis with iliac artery.

The tortuosity poses a problem when peak velocity measurements are needed to assess graft artery stenosis because of the normal acceleration as blood flows around a tightly curved artery. Awkwardly, the best places for Doppler measurements, the straight portions of the artery, are those that tend to lie parallel to the skin and thus subtend the worst beam-to-vessel angles.

Fig. 19

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

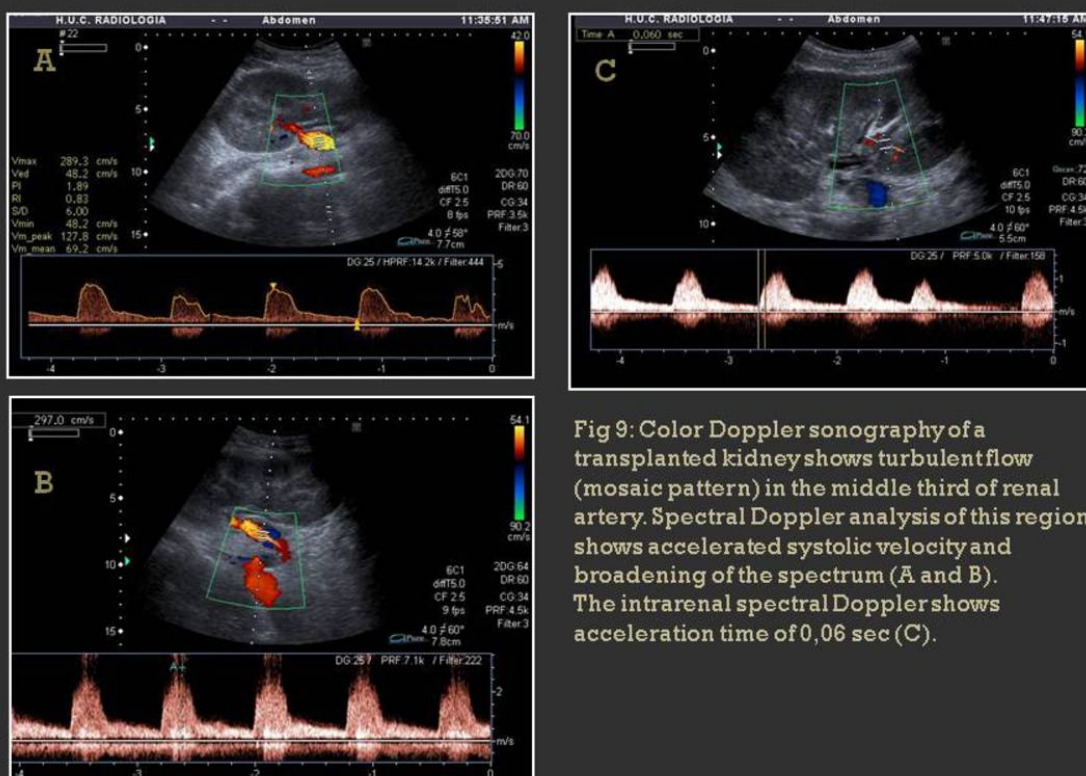


Fig 9: Color Doppler sonography of a transplanted kidney shows turbulent flow (mosaic pattern) in the middle third of renal artery. Spectral Doppler analysis of this region shows accelerated systolic velocity and broadening of the spectrum (A and B). The intrarenal spectral Doppler shows acceleration time of 0.06 sec (C).

Fig. 20

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications



Coronal CT image (D) and volume rendering image (E) of the same patient shows a significant stenosis (>60%) in the middle third of graft renal artery.

Fig. 21

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications



Contrast angiography findings: Hemodynamically significant RAS is suggested by a $> 60\%$ luminal narrowing of the renal artery diameter (arrow) (F).

Percutaneous transluminal angioplasty with or without stent placement is considered as a treatment of choice for RAS. In this case the stenosis was treated with stent placement (G).

Fig. 22

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS



Fig 10: Spectral Doppler shows near the arterial anastomosis a focal area of color aliasing with a peak systolic velocity of 670 cm/sec, which implies the presence of a severe stenosis or kinking of the anastomosis (A).

In the postnotic segment Doppler analysis shows a prolonged acceleration time (0,16sec) (B) and a decreased resistive index (0,33) (C) also suggesting a severe stenosis.

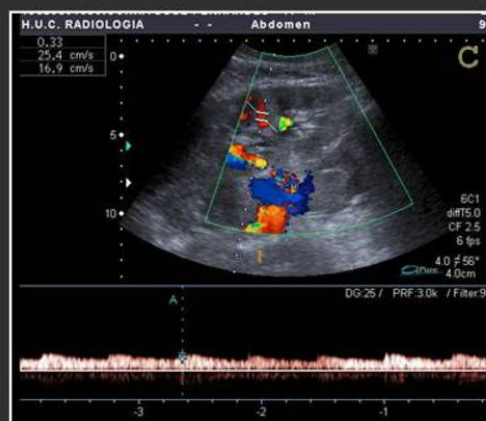
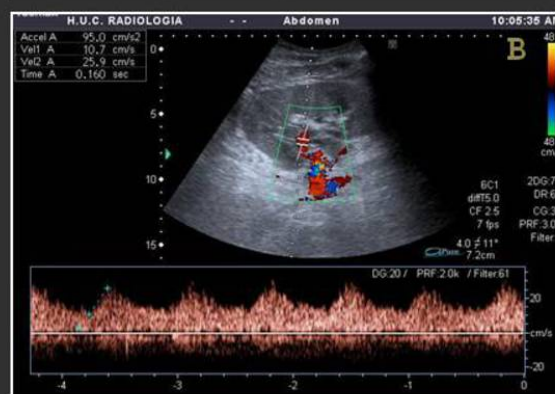
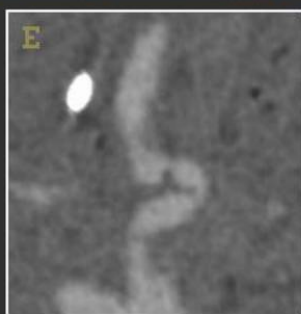


Fig. 23

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications



Volume rendering (D) and MIP (E) images and angiogram (F) show early bifurcation of the renal artery, immediately after the anastomosis. The main renal artery, that irrigates the two upper thirds of the transplanted kidney shows marked tortuosity 1,5cm after its emergence - very significant stenosis.

Fig. 24

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

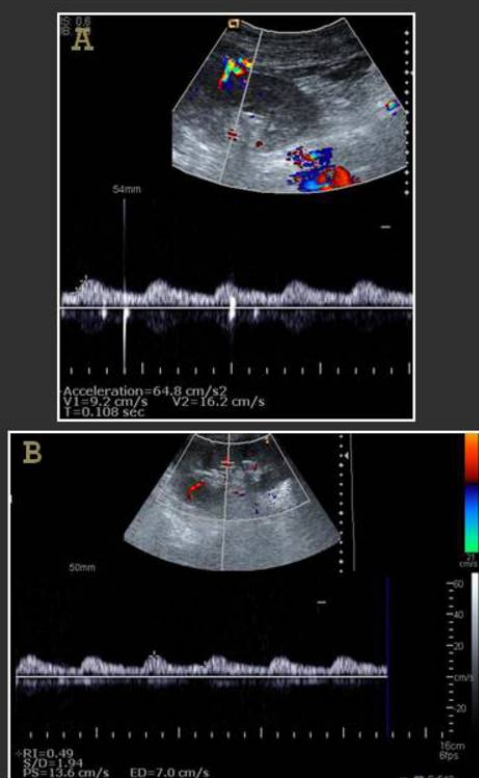


Fig 11: The intrarenal spectral study revealed an increased acceleration time (0,1sec), reduced amplitude of the systolic peak and reduction of the IR (0,46), with a parvus-tardus waveform, suggesting the possibility of stenosis upstream (A and B). Maximum intensity projection (MIP) image confirmed pre-occlusive stenosis of the renal artery (black arrow) immediately after anastomosis with the right iliac artery (C).

Fig. 25

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Kinking of renal artery



Fig 12: Grayscale US (A) and power-Doppler (B) show an image compatible with kinking of renal artery. Kinks of the renal artery may narrow the artery's lumen leading to an area of aliasing on color Doppler (C) and causing increased velocities at anastomosis (D), mimicking renal artery stenosis.

Fig. 26

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.2. Renal Artery Thrombosis

- Rare complication that occurs in < 1% cases
- Typically presents in the immediate postoperative period and the most common cause of thrombosis is acute or hyperacute rejection. It may also result from the surgical technique, such as kinking or torsion of the artery, and dissection of the arterial wall
- Since the renal graft has no collateral arterial blood supply, irreversible injury may result if the ischemic time exceeds 1,5 hours and results in transplant loss
- On Doppler sonography evaluation the most common finding is the absence of the arterial and venous flow distal to the thrombus and in the intrarenal vessels

Fig. 27

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications



Fig 13: Color Doppler US images (B and C) through the kidney demonstrate flow in the iliac vessels and in the very proximal part of the renal artery but no flow in the renal artery distally, vein or within the kidney.

Moreover, US (A) shows an enlarged kidney with multiple small hyperechoic foci related with areas of necrosis.

These findings are related with renal artery thrombosis.

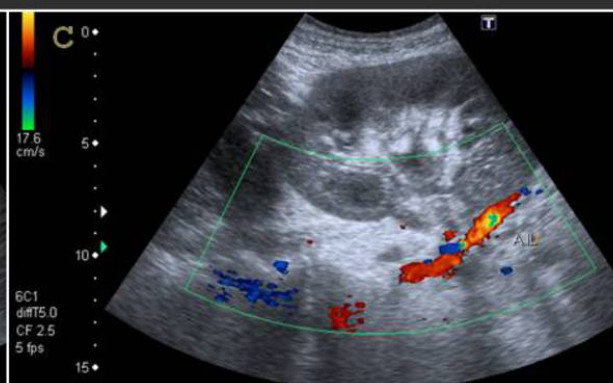
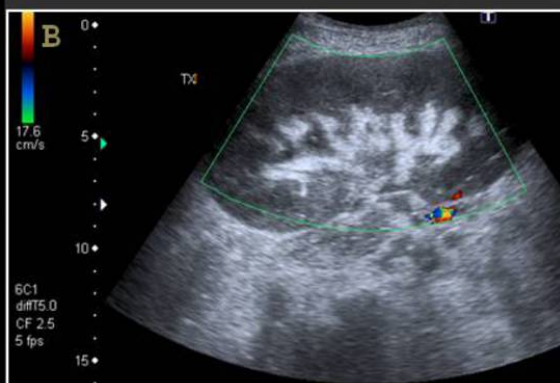


Fig. 28

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

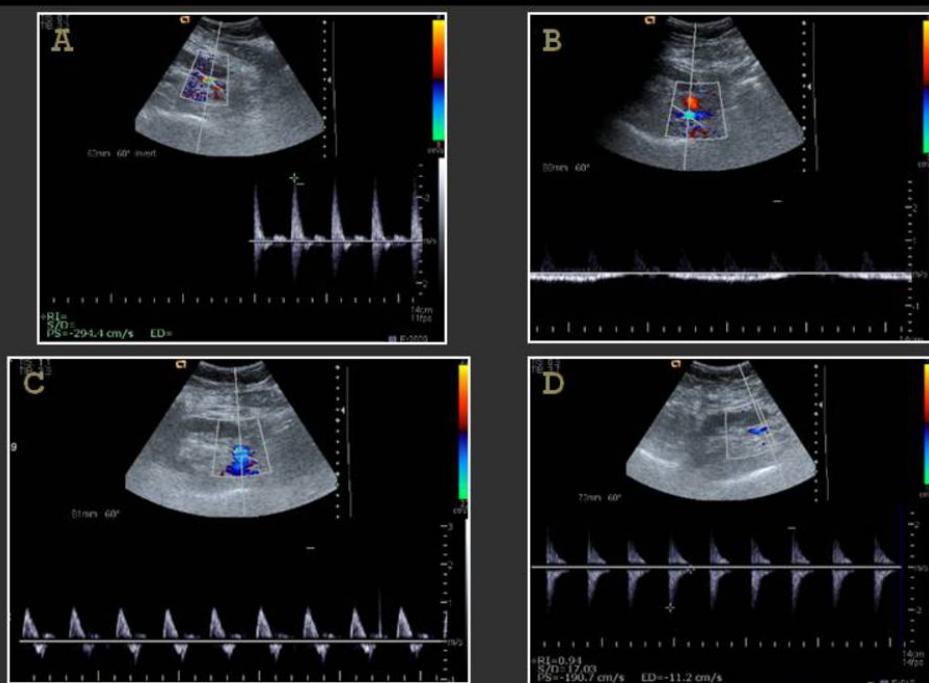


Fig 14: Spectral Doppler shows renal hypoperfusion, elevated resistive index (A) and decreased in venous flow (B) caused by acute rejection confirmed by biopsy. Few hours later there was reversed diastolic flow in most of the diastole (C), suggesting very high arterial resistance due to edema and arteritis. Several days later occurred occlusion of renal artery and vein (D).

Fig. 29

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications

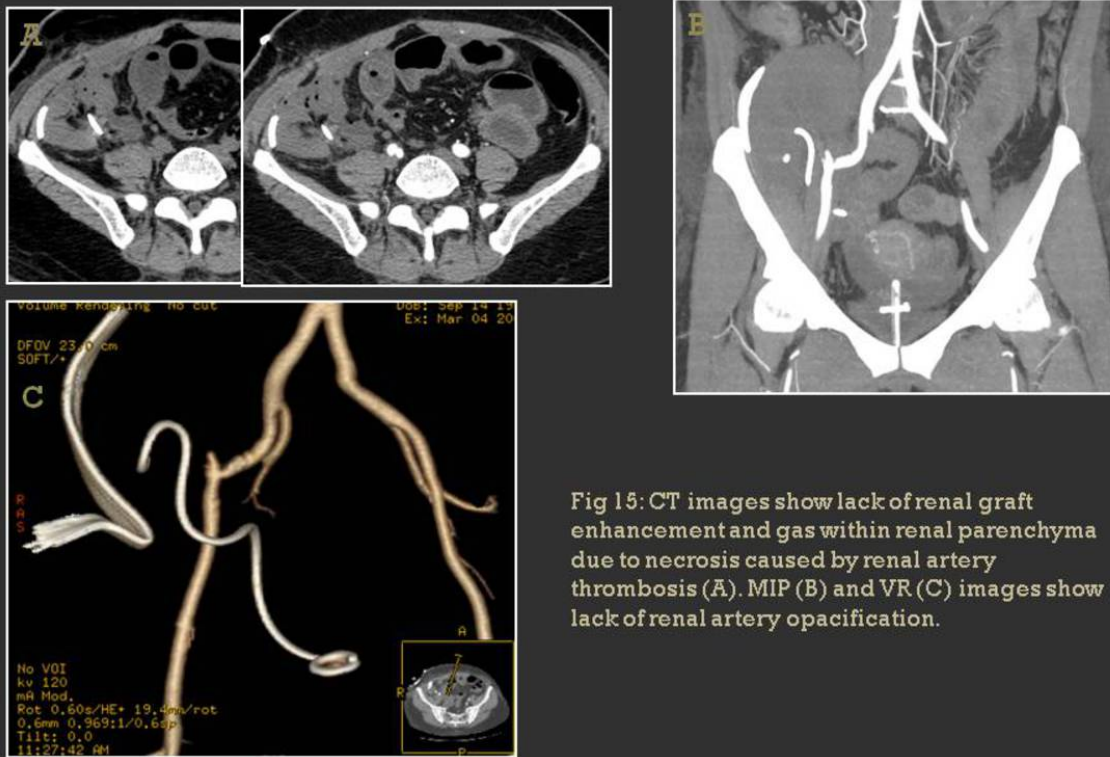


Fig 15: CT images show lack of renal graft enhancement and gas within renal parenchyma due to necrosis caused by renal artery thrombosis (A). MIP (B) and VR (C) images show lack of renal artery opacification.

Fig. 30

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.3. Renal Vein Thrombosis

- Uncommon complication occurring in less than 4% of renal transplants in the first week post-transplantation
- Abrupt onset of graft tenderness, swelling, oliguria, proteinuria and impaired renal function
- Etiologies include surgical complications, hypovolemia, extension of iliac thrombosis and compression by fluid collections
- Us findings include enlarged kidney, decreased echogenicity of the parenchyma, loss of cortico-medullary distinction and effacement of renal sinus and collecting system. Sometimes can be seen an echogenic thrombus in the vein
- Doppler findings:
 - Absence of color and waveform flow in the renal vein
 - Diastolic reversal of flow in the renal artery

Fig. 31

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS



Fig 16: Color Doppler sonogram image through the renal hilum shows arterial flow but absence of color in the renal vein and very little flow within the transplanted kidney (A). Spectral Doppler waveform image of a segmental artery demonstrates reversed diastolic flow in most of the diastole suggesting very high arterial resistance. These findings are compatible with renal vein thrombosis (B).

Fig. 32

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.4. Renal Vein Stenosis

- Uncommon complication occurring secondary to compression from perinephric fluid collections, masses or from perivascular fibrosis; acute rejection; infection; kinking

RENAL VEIN STENOSIS ↔ PARCIAL RENAL VEIN THROMBOSIS

- The renal parenchyma may be normal or slightly hypoechoic
- **Doppler findings:**
 - Narrowing of the vessel
 - Increased velocity in the vein (↑ 3 to 4 fold) from prestenotic to stenotic area
 - Increased resistive indexes within intrarenal arteries

Fig. 33

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

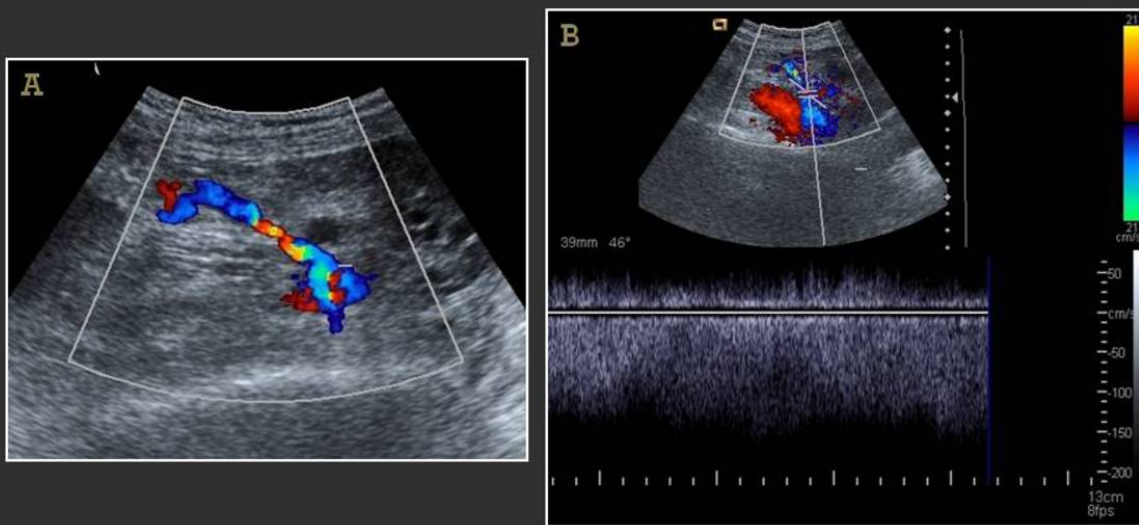


Fig 17: Color Doppler sonogram of a transplanted kidney demonstrates narrowing and turbulent flow in the main renal vein (A). Doppler sonogram demonstrates high velocity flow within the renal vein near the anastomosis, suggesting renal vein stenosis (B).

Fig. 34

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications

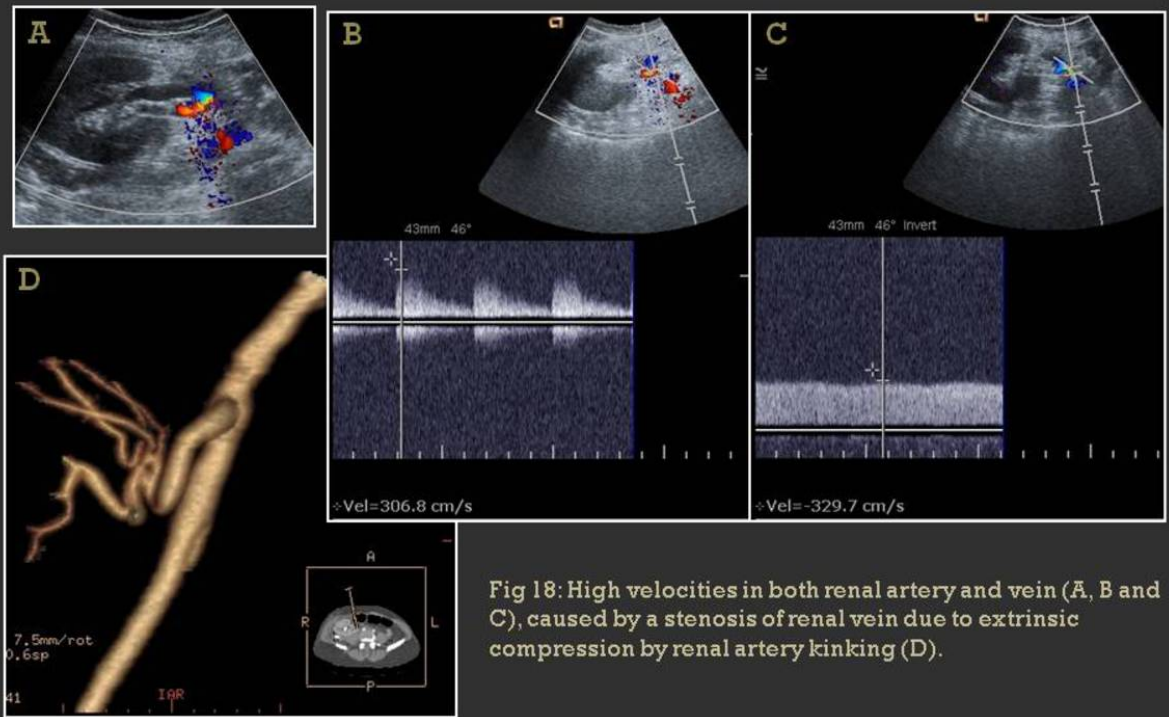


Fig 18: High velocities in both renal artery and vein (A, B and C), caused by a stenosis of renal vein due to extrinsic compression by renal artery kinking (D).

Fig. 35

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.5. Thrombosed dissection of the common iliac artery

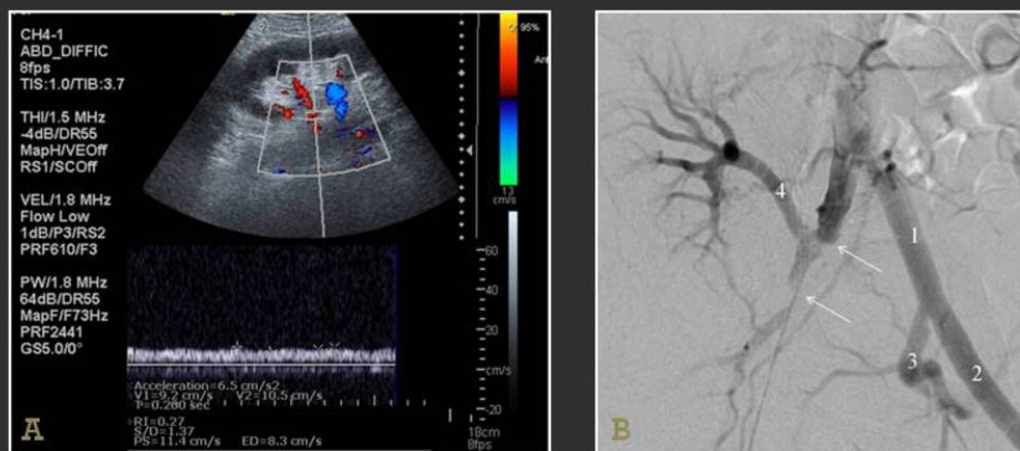


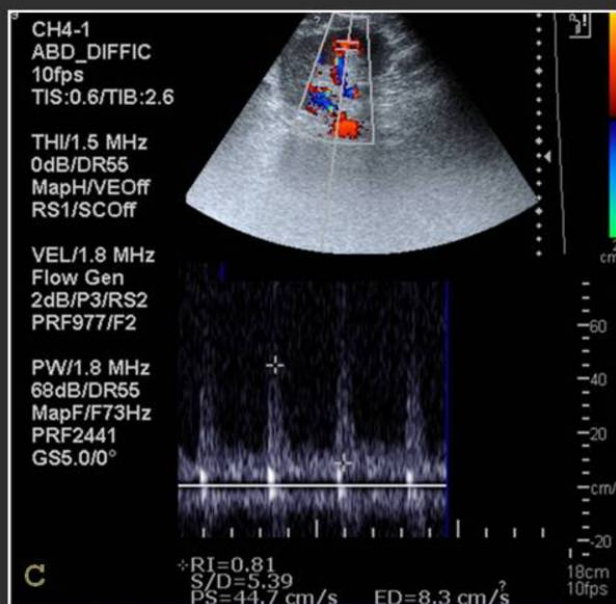
Fig 19: Doppler sonography in the first day after transplant reveals a poorly perfused kidney allograft. The intrarenal study exhibited a *tardus parvus* waveform with a slow systolic upstroke, a rounded and diminished peak systolic velocity, and a low resistivity index. These features indicate severe proximal arterial obstruction (A). Angiography documented a filling defect of the external iliac artery proximal to the vascular anastomosis with stenosis of the arterial lumen (arrows) with diminished and slow contrast filling of its branches. The early postoperative period and the morphology of the lesion suggested superimposed thrombosis. The transplant renal artery (4) had regular caliber and emerged from the true lumen, therefore the ischemia being related to stenosis of the true lumen and not by direct compromise (B) (1-left common iliac artery, 2-left external iliac artery, 3-left internal iliac artery).

Fig. 37

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications



Doppler sonography in the first day after vascular surgical revision. An intrarenal waveform spectrum with brisk systolic upstroke, low end-diastolic flow, and a high resistivity index was demonstrated. These Doppler findings are compatible with acute tubular necrosis (C).

Fig. 38

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.6. Common iliac artery stenosis/thrombosis

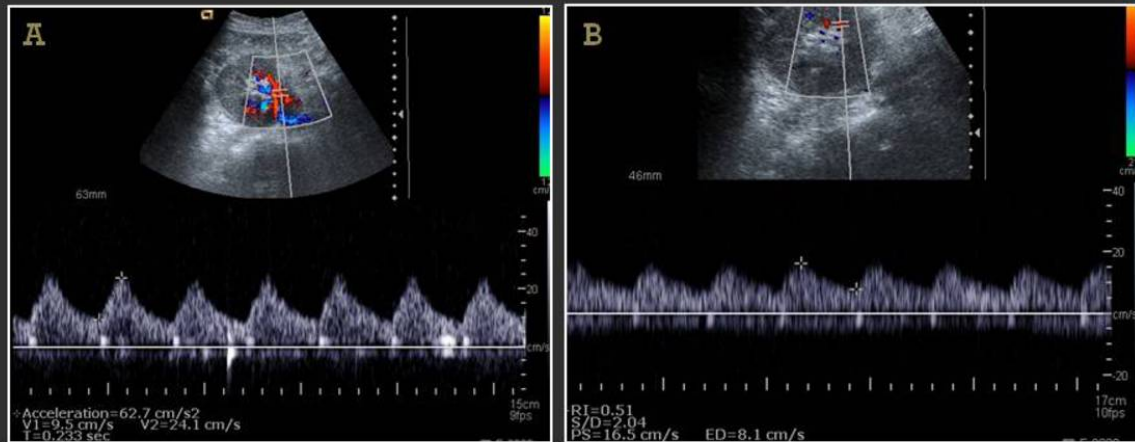


Fig 20: Spectral Doppler shows, distally in the main renal artery (A), and in intrarenal arteries (B) a parvus-tardus waveform, with delayed systolic upstroke (0,23 sec) and a resistive index of 0,54 suggestive of proximal stenosis.

Fig. 39

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications



CT images demonstrates thrombosis of the left common iliac artery immediately after the aortic bifurcation and ending just before the surgical anastomosis of the renal artery. These images also show an insufficient enhancement of the renal graft, specially in the anterior third, that correlates with a hypodense area of infarction (C and D). There were iliac repermeabilization downstream by collateral circulation as we see in the volume rendering image (E).

Fig. 40

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications



Angiogram shows absence of flow in the proximal part of common iliac artery and confirmed stenosis. There is repermeabilization of the distal part of this artery by collateral circulation (A). Another angiogram shows the placement of a stent in the proximal part of common iliac artery (B). Angiogram obtained after stent placement shows restoration of a near normal arterial lumen (not shown).

Fig. 41

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.7. Segmental Infarction

- Results from thrombosis of the intraparenchymatous arteries
- The infarcts may be seen as focal hypoechoic areas that may have echogenic borders



Fig 21: US and CT images show a hypoechoic and a hypodense areas respectively, within renal parenchyma, that corresponded to segmental infarction.

Fig. 42

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.8. Arteriovenous fistulas and Pseudoaneurysms

Complications – Vascular Complications

- Occur after a renal biopsy – affecting 1-18% of cases of transplant biopsies
- Both conditions usually have a self limiting course and resolve spontaneously
- In rare instances, an AVF may be large enough to cause decreased graft perfusion leading to renal ischemia. Pseudoaneurysms may cause complications if they rupture.
- When these lesions are large may be required transcatheter embolization to treat them
- Extrarenal pseudoaneurysms are very rare but when ruptures they are associated with a high mortality rate. They are associated with surgical technique. In those cases, transplant nephrectomy may have to be performed

Fig. 43

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.8.1. Arteriovenous fistulas

- An arteriovenous fistulas (AVF) forms when both arterial and venous walls are involved by the needle biopsy, creating a fistulous connection between the two
- They resolve spontaneously, without treatment, within 1-2 years in about 70% of the cases
- In most cases they are no morphologic changes detectable with grayscale sonography
- Doppler findings:
 - Focal area of aliasing and “peri-vascular” artefact due to perivascular soft tissue vibration
 - Very high velocity in the area of AVF
 - Low resistive index in the feeding artery
 - High velocity arterialized venous flow (could also be continuous flow) in the draining vein

Fig. 44

References: L. Andrade; Radiology, Coimbra, PORTUGAL

Complications – Vascular Complications

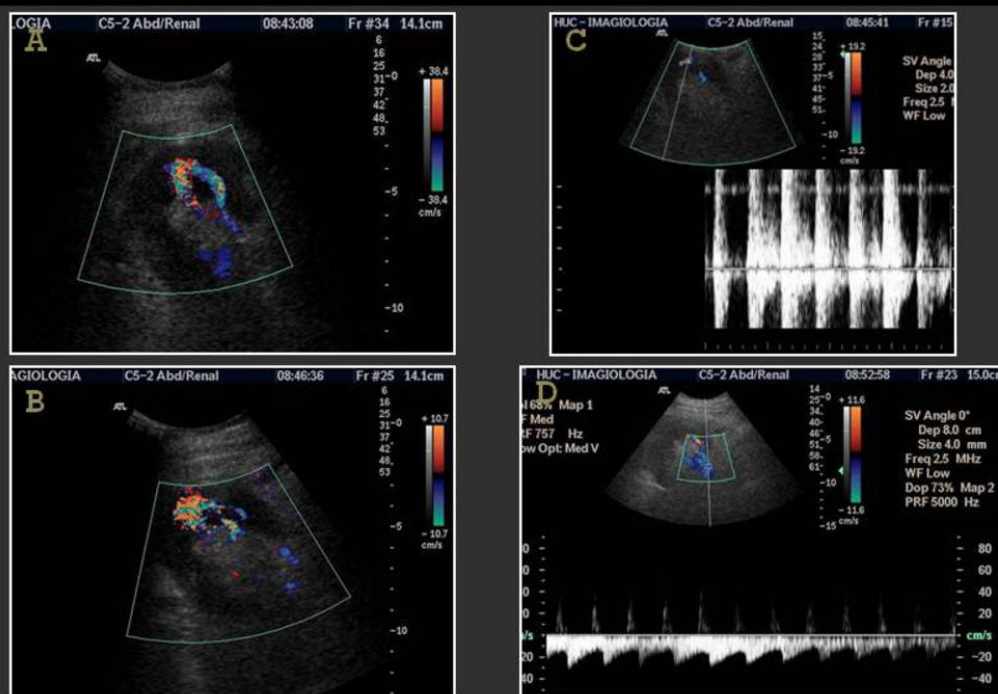


Fig 22: Arteriovenous shunt post surgery presenting as a focal lesion with increased vascularity on color Doppler ultrasound, with a feeding artery and a draining vein (A). Large focal area of aliasing and tissue vibration due to an AVF (B). Close to the area of AVF demonstrate high velocity with a high diastolic flow (C). High velocity "arterialized" venous flow (D).

Fig. 45

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS



Fig 23: Sonogram of a renal transplant shows a focal area of aliasing (A). Duplex Doppler sonogram in the same patient demonstrates a high-velocity, low-resistance waveform characteristic of an AVF. The peak systolic velocity was 177 cm/sec, the diastolic velocity was 115 cm/sec and low resistive index (0,04) (B and C).

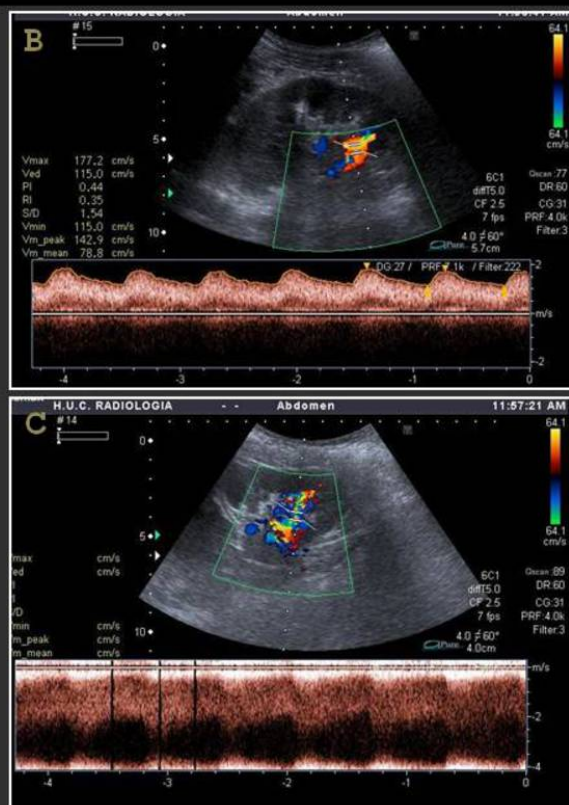


Fig. 46

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

2.8.2. Pseudoaneurysm

- They are formed when only the arterial wall is injured by the biopsy needle and may also occur as a consequence of infection within the graft or dehiscence of arterial anastomosis
- Pseudoaneurysms appear as cystic spaces on gray-scale images
- **Doppler findings:**
 - Swirling pattern of internal blood flow
 - Biphasic “to and fro” pattern of flow in the neck of the pseudoaneurysm
 - Renal pseudoaneurysms are often associated with na AVF. In those cases, the flow progresses from the feeding artery to the pseudoaneurysm and then to the draining vein. Therefore, the “to and fro” flow pattern is replaced by a low-resistance high velocity pattern

Fig. 47

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

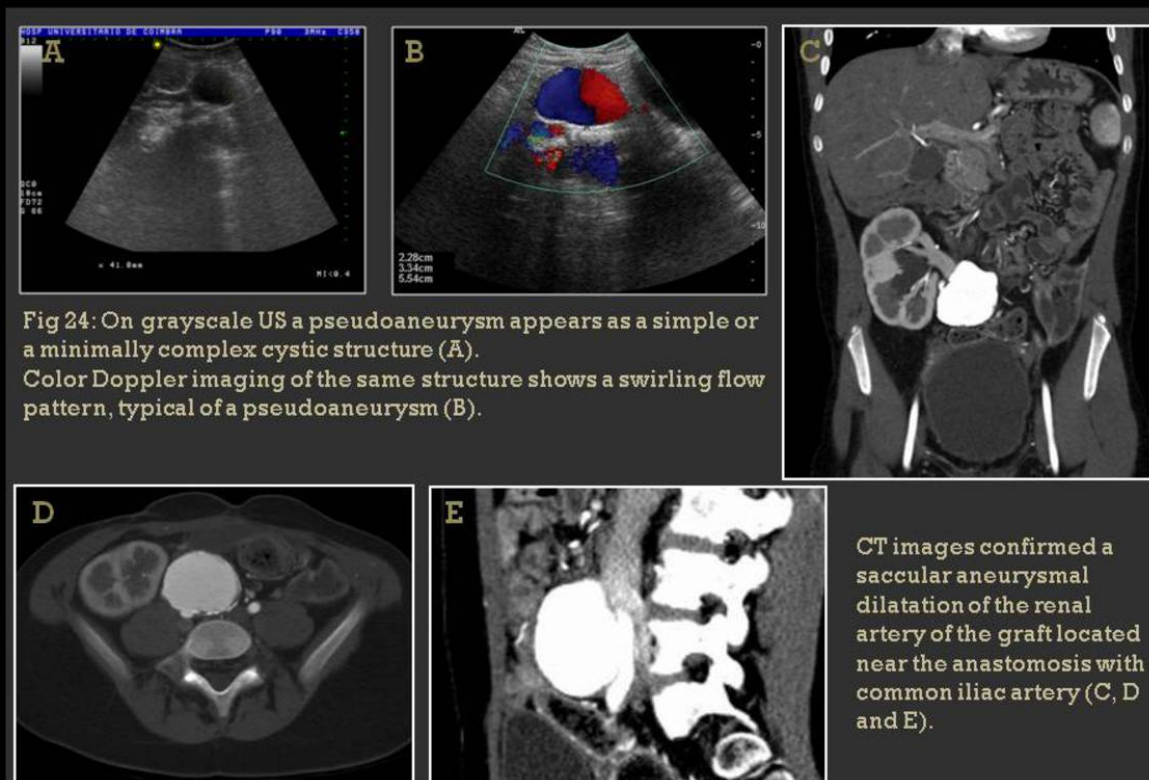
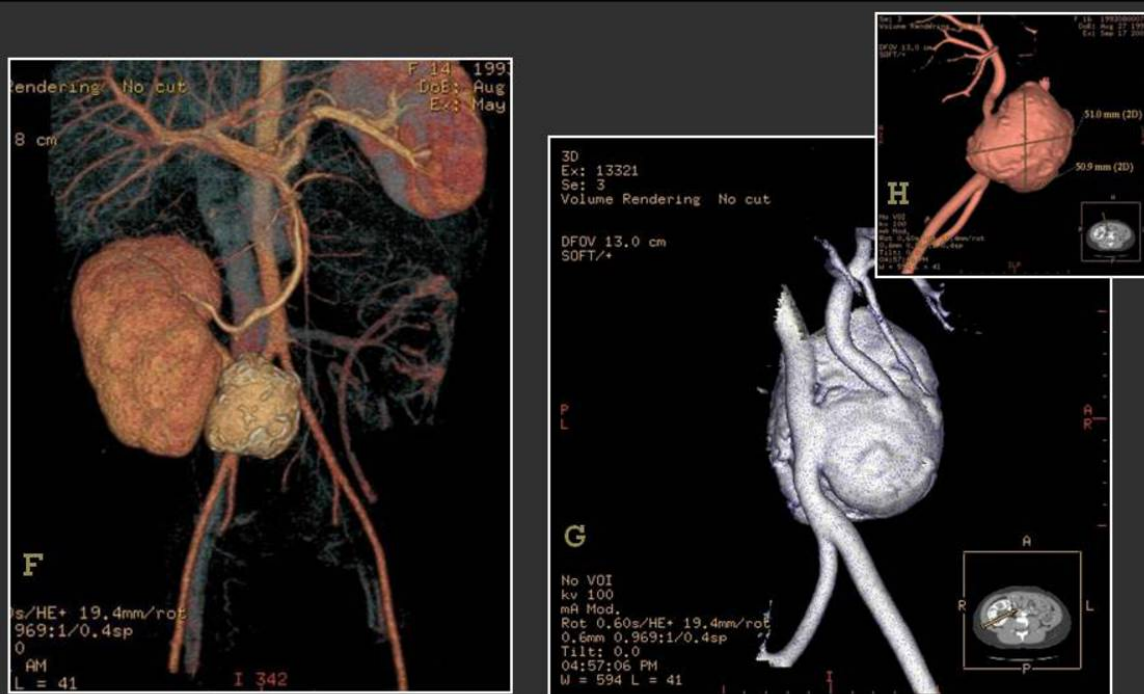


Fig. 48

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Vascular Complications



Volume rendering images of the same patient with an aneurismatic renal artery of the transplanted kidney (F, G and H).

Fig. 49

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

COMPLICATIONS

3. COMPLICATIONS OF COLLECTING SYSTEM

- The incidence of urological complications is about 1%-8% and they are seen most frequently during the first month after transplant
- The most common urological complications are ureteric obstruction and urine leak
- Others complications include thickening of the urotelium and formation of stones in the transplant kidney

Fig. 50

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

3.1. Ureteral Obstruction

- Urinary obstruction is seen in about 2% of cases
- Mild dilatation of the collecting system and the ureter is commonly seen due to loss of tonicity from deservation
- Hydronephrosis clinically significant may be due to edema at the ureteral anastomosis, ischemia causing stricture (more common in the distal third of the ureter), infection, perinephric fluid collections causing compression or kinking of the ureter
- Other rare causes of obstruction includes stones, papillary necrosis, clots, fungi and pelvic fibrosis
- The US shows dilated renal pelvis and calyces and may also suggest pyonephrosis, fungal infections, clots or tumor by showing internal echogenicity within the collecting system
- In some cases of obstructive hydronephrosis may be seen an increased resistive index

Complications – Collecting System

Fig. 51

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Collecting System

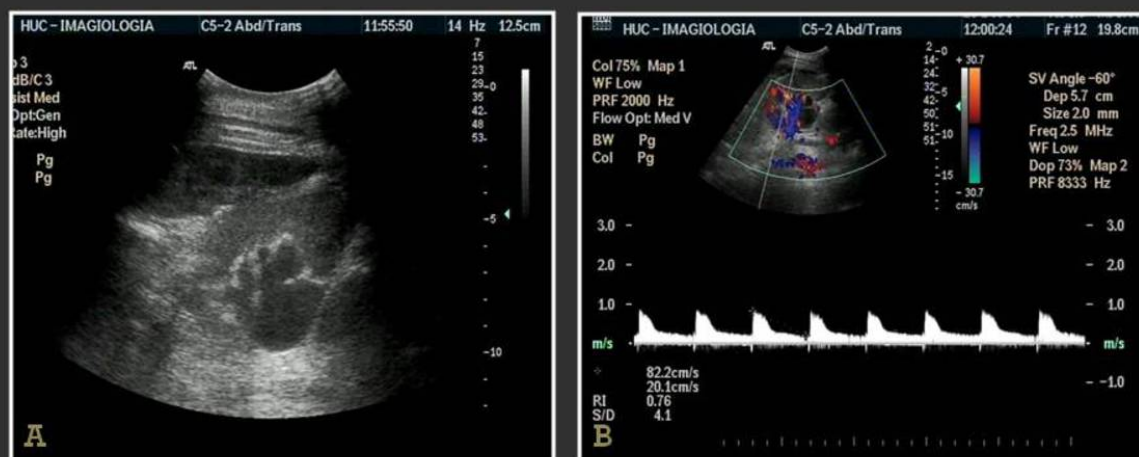


Fig 25: Obstructive hydronephrosis. Grayscale US shows moderate obstructive hydronephrosis and dilated proximal ureter (A). Duplex US of the same patient shows increased resistive index suggesting obstructive hydronephrosis, although not a specific finding (B).

Fig. 52

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

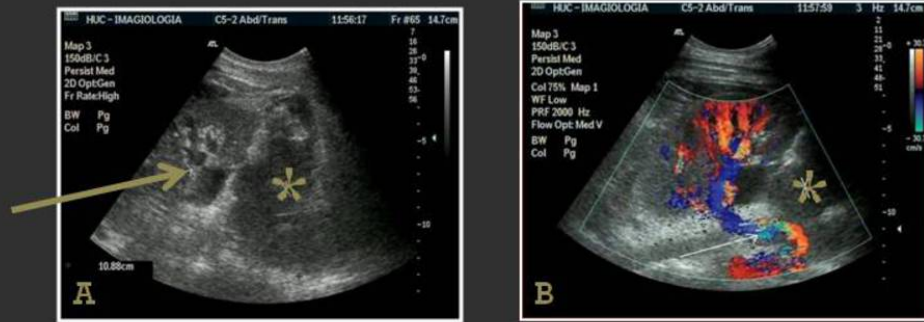


Fig 26: Obstructive hydronephrosis (arrow) due to a retroperitoneal hematoma (*) (A and B).

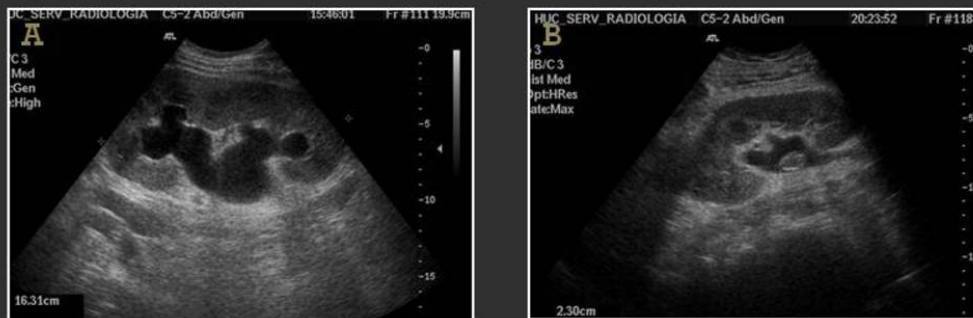


Fig 27: Hydronephrosis secondary to a blood clot. US shows an echogenic mass in a patient who undergone a renal biopsy recently compatible with a blood clot (A and B).

Fig. 53

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Collecting System

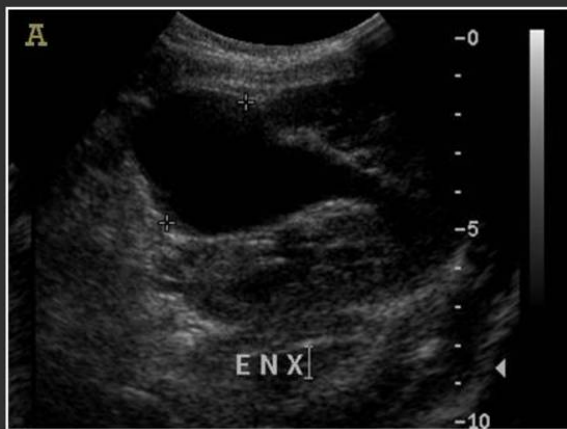


Fig 28: US show hydronephrosis and hydroureter (A). A plain radiograph (with contrast) in the same patient taken after percutaneous nephrostomy tube placement shows the dilated collecting system and the stenosis of the ureter (B).



Fig. 54

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

3.2. Neoplasm

Complications – Collecting System



Fig 29: Large dilatation of the collecting system (5.7cm) of a transplanted kidney (A). A polypoid lesion measuring 31mm with a vascular pedicle was observed and turned out to be a transitional cell carcinoma (B).

Fig. 55

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

COMPLICATIONS

4. PARENCHYMAL ABNORMALITIES

- The causes of decline in renal function include acute tubular necrosis (ATN), rejection (hyperacute, acute or chronic) and drug nephrotoxicity.
- The differential diagnosis by imaging of these conditions is extremely difficult. Doppler findings are overlapping: increased resistive indexes and diastolic reversal of flow in the renal artery (differential diagnosis between this 3 entities and renal vein thrombosis).
- Is necessary a core needle biopsy to differentiate between these conditions.
- The renal parenchyma can also be involved with focal processes (abscess, cyst, tumor, focal infarct).

Fig. 56

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

4.1. Acute Tubular Necrosis

- The most common cause of impaired renal function in the early posttransplant period
- The initial cause of ATN is related to the process of the transplant itself that causes a reversible ischemic damage to the renal tubular cells prior to engrafting. The reperfusion after the transplant may lead to oxygen free radical injury
- Usually self-limiting, resolving in 2 weeks
- Most common in cadaveric transplants than in living related donors, affecting 20-60% of cadaveric renal grafts in the first 48 hours after transplantation
- US is usually normal or may show nonspecific findings, such as renal enlargement, changes in the echogenicity of the parenchyma or pyramids, or increased resistive indexes (above 0,8)

Fig. 57

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

4.2. Rejection

4.2.1. Hyperacute Rejection

- Uncommon. Due to the presence of preformed antibodies in the recipient and occurs immediately after the anastomosis so it is diagnosed in the operating room by the surgeons and the kidney graft is promptly removed

4.2.2. Acute Rejection

- The most common type of rejection, affecting 10-40% of transplants. Occurs in 1-3 weeks following surgery
- US may be normal or may show graft enlargement due to edema, decreased cortical echogenicity and swelling of the medullary pyramids resulting in loss of cortico-medullary differentiation
- Doppler US usually show high resistive indexes ($>0,9$). In severe cases shows reduced, absent or reversed diastolic flow in the renal artery (differential diagnosis with renal vein thrombosis).

4.2.3. Chronic Rejection

- The most common cause of late graft failure. Occurs after the first 3 months of transplantation and results in vascular compromise of the graft and insidious decline in renal function.
- US may be normal or show a small graft with increased parenchymal echogenicity, cortical thinning and mild hydronephrosis
- Values of resistive indexes greater than 0,7 in the intrarenal arteries may indicate this condition
- Renal biopsy is necessary because the diagnosis is histological

Fig. 58

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

4.3. Drug Toxicity (Ciclosporina)

- Most of the immunosuppressive drugs that are routinely given to the transplant patients to avoid episodes of transplant rejection are nephrotoxic
- Ultrasound findings are nonspecific and frequently normal

Fig. 59

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Parenchymal Abnormalities

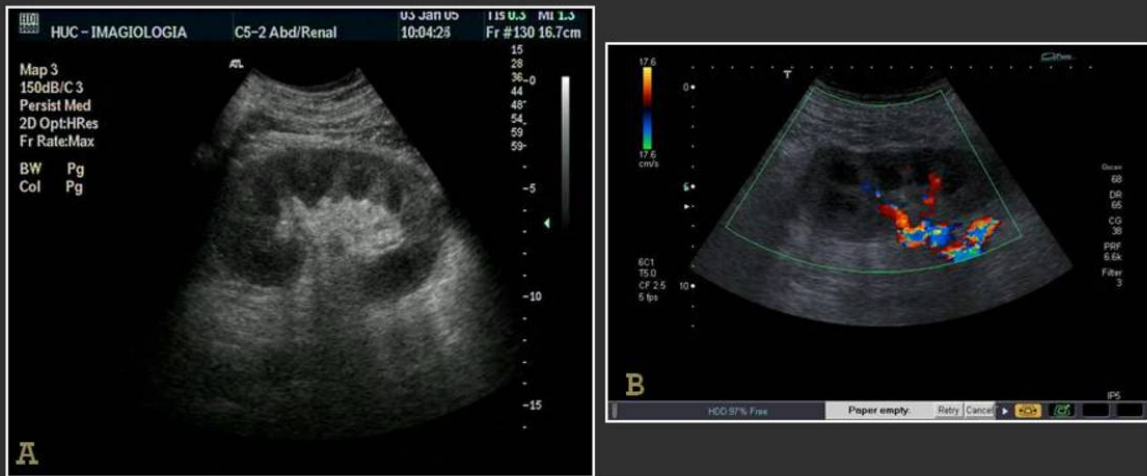


Fig 30: US shows enlargement and increased parenchymal echogenicity of the renal graft (A). Doppler US shows the same findings as in US image and also decreased of intra-renal vascularity (B). This findings are non specific.

Fig. 60

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Parenchymal Abnormalities

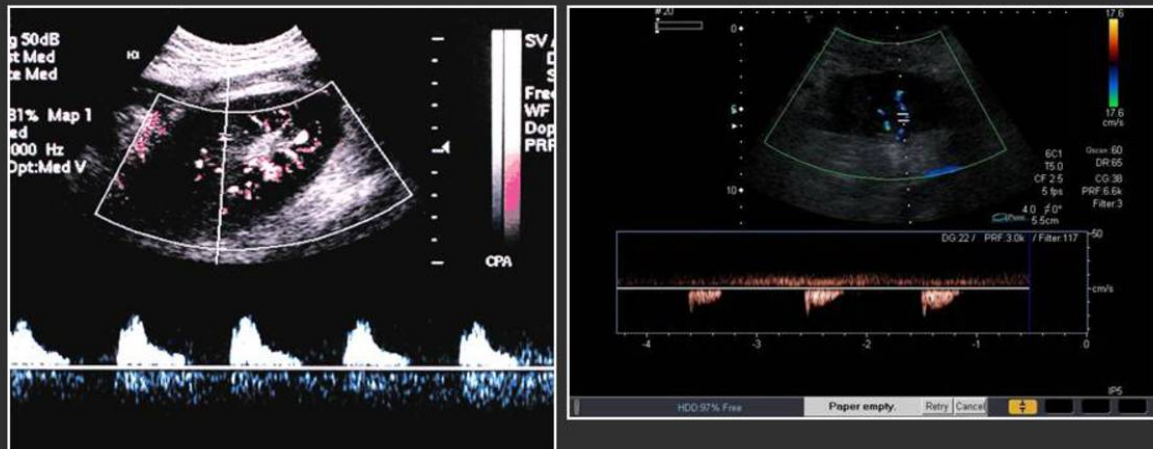


Fig 31: Two cases of acute rejection. Spectral Doppler shows absent diastolic flow in both cases.

Fig. 61

References: L. Andrade; Radiology, Coimbra, PORTUGAL

IMAGING FINDINGS

Complications – Parenchymal Abnormalities

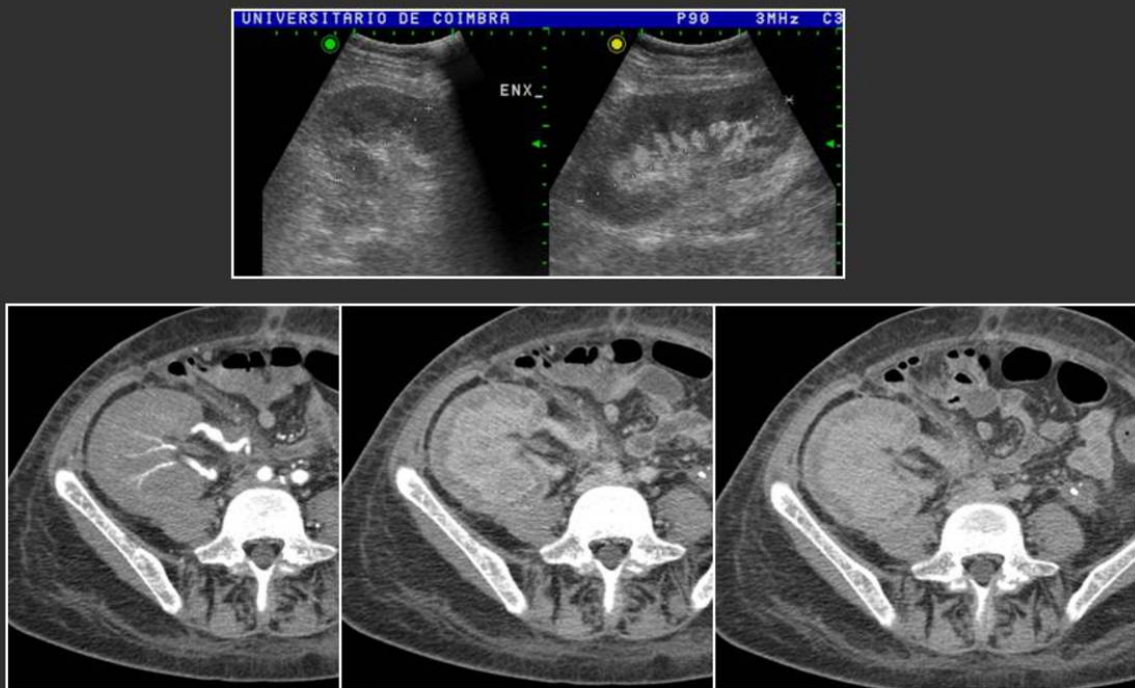


Fig 32: Acute rejection was the cause of the discrete enhancement of the cortical reflecting necrosis.

Fig. 62

References: L. Andrade; Radiology, Coimbra, PORTUGAL

Conclusion

CONCLUSION

- Doppler sonography usually identifies not only renal ischemia after renal allograft transplantation, but also all the major associated complications, and allows a noninvasive triage of patients for angiography or surgery correction.
- Typical pathologic patterns of flow can target the radiologist to a precise diagnosis.
- Vascular abnormalities represent most of the complications, yet it is very important to recognize early signs of nonvascular pathology.

Fig. 63

References: L. Andrade; Radiology, Coimbra, PORTUGAL

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