Ultrasonographic Evaluation of Kidney Transplant

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Learning objectives

- To demonstrate the role of triplex ultrasonography (US) in the evaluation of the renal transplant.
- To review and illustrate the normal post-operative findings and possible complications detected by triplex US.

Background

Renal transplantation is the preferred treatment method of end-stage renal disease. Despite advances in peritoneal dialysis and hemodialysis, post-transplant survival is greater.

Triplex US is the first line diagnosis modality in the immediate post-transplant period as well as for long-term follow-up.

In order to interpret correctly the sonographic findings in renal transplant recipients, a comprehensive knowledge of the transplantation technique and the postoperative imaging anatomy is required.

The kidney graft is placed extra-peritoneally in the recipient contralateral iliac fossa. The right iliac fossa is preferred. An end to side anastomosis is made between the donor renal artery and the recipient external iliac artery, and the donor renal vein and the recipient external iliac vein. Multiple renal arteries can be anastomosed as a Carrel patch, joined together, or anastomosed separately. In such cases, correlation to the operative report or diagram is often essential in understanding the transplant anatomy. The urinary drainage is obtained by implantation of the donor ureter into the dome of the recipient's bladder.

Findings and procedure details

NORMAL RENAL TRANSPLANT ULTRASOUND

The sonographic evaluation of the graft is easily performed because of its superficial location. The transplant is usually parallel to the surgical incision, with the hilum oriented.
inferiorly and posterioly. The healthy transplanted kidney has comparable ultrasound appearance to the healthy native one. The graft superficial location allows for normal corticomedullary differentiation of the renal parenchyma. In the first 6 months the normal kidney may increase in volume up to 40%. Small crescentic peritransplant collections in the immediate postoperative period are normal findings (mentioned in detail next) (Fig. 12).

On Doppler evaluation the normal renal artery has a low resistance anterograde only continuous flow, and the normal renal vein a low velocity monophasic or demonstrates some pulsality with cardiac cycle.

The Doppler evaluation of the parenchyma, demonstrates antegrade-only continuous flow, with an homogeneous distribution. The normal inter-lobar arteries have a resistive index (RI) between 0.55 and 0.8 (Fig.s 1 to 6).

COMPLICATIONS OF RENAL TRANSPLANTATION

Post-transplant complications can be divided in functional, urologic, vascular, peri-transplant collections, infectious and neoplasm.

1) Functional complications

- Acute tubular necrosis, rejection (acute and chronic) and drug toxicity
- Acute and chronic rejection are the most frequent causes of graft loss in the immediate post-operative period and late period, respectively
- Triplex US findings:
  - nonspecific
  - elevated RI in the inter-lobar arteries (#0.8)
  - may have altered parenchymal echogenicity and thickness

Differentiation of these entities requires ultrasound guided biopsy

2) Urologic complications

2.1) Urinary obstruction

- Usually occurs in the first 6 months after transplantation
- 90% within the distal third of ureter
• Causes: (a) main cause is ischemic stricture (the terminal ureter has limited vascular supply from the renal artery); (b) other causes are ureteral kinking, perigraft fibrosis, extrinsic compression from peri-graft collections or masses, clots, calculi or tumors and previously unrecognized uretero-pelvic junction obstruction
• Mild to moderate pylocaliectasis may be secondary to non-obstructive causes: overhydration, full bladder (the transplant should then be evaluated after emptying the bladder), previous hydronephrosis (the transplanted collecting system has no tone because is denervated)
• Triplex US findings:
  - hydronephrosis (Fig.7)
  - may have elevated RI in the inter-lobar arteries (#0.8)

2.2) Urinoma
  • Usually found in the first two weeks after surgery
  • Result from leak (a) at the ureteroneocystomy site; or (b) at the distal ureter, possibly as a result of necrosis due to ischemia
  • Rarely result from leak caused by high grade collecting system obstruction
  • Triplex US findings:
    - anechoic, well defined, with no septations collection
    - usually between the renal graft and the bladder
    - increase in size rapidly

3) Vascular complications

3.1) Renal artery stenosis
  • The most common vascular complication
  • Occurs within the first year after surgery
  • Half of cases occur at the site of the vascular anastomosis (due to surgical technique or rejection) (Fig. 8 and 9)
  • Can occur at the donor portion or the recipient portion
  • Triplex US findings:
    - aliasing in the region of narrowing
    - high peak systolic velocity (PSV) # 200 cm/sec
    - velocity gradient between the stenotic and prestenotic
segments #2:1

- tardus parvus waveform in the inter-lobar arteries

3.2) Arterial thrombosis

- Occurs within the first month of surgery
- Causes: related to surgical technique, acute rejection
- Global infarction (main artery affected) or segmental infarctation (major arterial branch affected, accessory renal artery affected, vasculitis)
- Triplex US findings:

- global infarction:
  - infarcted graft becomes enlarged, hypoechoic and heterogeneous
  - distal to occlusion, absence of arterial and venous flow in both main and inter-lobar vessels
- segmental infarction (Fig. 10)
  - hypoechoic region or mass, or hypoechoic mass with a echogenic wall
  - wedge shaped area without arterial or venous flow
  - differential diagnosis with severe pyelonephritis or transplant rupture

3.3) Arteriovenous fistula

- Intraparenchymal, after biopsy (Fig. 11)
- Small, resolve spontaneously
- Rarely, clinically significant (affecting renal graft function)
- Triplex US findings:

- focal parenchymal region with aliasing
- low resistance, high velocity waveform

3.4) Pseudoaneurysm
• Intraparenchymal: post biopsy
• Extrarenal: at the vascular anastomosis, caused by surgical technique or infection
• All are clinically significant (risk of infection and rupture)
• Triplex US findings:

- simple or complex cyst
- to-and-fro spectral Doppler flow pattern

3.5) Renal vein thrombosis

• Occurs in the first postoperative week
• Causes: technical problems at the anastomosis, rejection, compression from a peri-transplant fluid collection
• Triplex US findings:

- renal graft may appear enlarged
- venous flow is reduced or absent
- reversal of diastolic flow in the arterial waveform

3.6) Renal vein stenosis

• Causes: perivascular fibrosis, compression by perinephric fluid collections
• Triplex US findings:

- aliasing at the stenotic segment
- threefold to fourfold increase in velocity across the region of narrowing

4) Peritransplant fluid collections

• Observed in 50% of renal transplants
• Hematoma, seroma, urinoma, lymphocele, abscess
• Clinical significance is determined by size, location and possible growth
• When sufficiently large may cause complications related to mass effect on the transplant:

- hydrenephrosis,
- kinking of the vascular pedicle (which can lead to stenosis,
thrombosis)
- compromised parenchymal perfusion
- other
  - Time interval after transplantation may help to differentiate:
- hematoma and urinoma - immediate postoperative period
- lymphocele - 4-8 weeks after surgery
  - Triplex US findings are nonspecific
  - Percutaneous aspiration is the only safe way to diagnosis

4.1) Hematoma
  - The majority of post-operative fluid collections are due to hematomas and seromas (sero-sanguinous fluid collection), most insignificant clinically and resolve spontaneously (Fig. 12)
  - Other causes: trauma, post biopsy
  - Triplex US findings:
    - nonspecific
    - complex collection with echogenicity depending on age

4.2) Lymphocele
  - The most common peritransplant fluid collection
  - Occurs 4-8 weeks after surgery
  - May develop years after transplantation
  - Result from leakage of lymph from surgically disrupted lymphatic channels
  - The most common fluid collection to result in ureteric obstruction
  - Triplex US findings:
    - anechoic collection that may have internal septations

4.3) Urinoma
  - Described previously

4.4) Abcess
  - Caused by pyelonephritis or arise from a previously sterile collection
  - Triplex US findings:
    - nonspecific
- air within a collections without a history of recent percutaneous, is highly suggestive

5) Other complications
   - Infections
     - Pyelonephritis, emphysematous pyelonephritis, pyonephrosis
       - Calculous disease
       - Neoplasm
   - Skin cancer, lymphomas, renal adenocarcinoma in the native kidney, urothelial tumor
     - Post-transplantation lymphoproliferative disorder

If triplex US findings are inconclusive or if there is high clinical suspicion of graft dysfunction with negative US findings, other imaging modalities such as Angio-MRI and Angio-CT (with proper regards concerning nephrotoxicity of the iodine contrast) can be considered.

**Images for this section:**
**Fig. 1:** Normal gray-scale US of renal transplant. Notice the normal corticomedullary differentiation.

**Fig. 2:** Color Doppler showing normal homogeneous blood flow throughout the transplant kidney (upper third).
**Fig. 3:** Color Doppler showing normal homogeneous blood flow throughout the transplant kidney (middle third).

**Fig. 4:** Color Doppler showing normal homogeneous blood flow throughout the transplant kidney (lower third) and arterial and venous normal anastomosis.
Fig. 5: Color and spectral Doppler showing normal, low resistance, continuous flow in the renal graft artery.
**Fig. 6:** Color and spectral Doppler showing normal inter-lobar artery, with RI between 0.55 and 0.8.
Fig. 7: Gray scale US showing hydronephrosis secondary to distal ureter stricture (not shown).
**Fig. 8:** Color and spectral Doppler showing focally elevated peak systolic velocities in renal graft artery (measuring up to 290 cm/sec), in the setting of arterial stricture.

**Fig. 9:** Same patient as in Fig. 8. Angio-CT showing arterial anastomotic stenosis.
**Fig. 10:** Focal diminished parenchymal thickness secondary to polar infarction, due to lesion during surgery to a low accessory renal artery.

**Fig. 11:** Color and spectral Doppler showing renal graft post-biopsy arteriovenous fistulae, with aliasing and high velocity, low resistance waveform.
Fig. 12: Gray scale US of renal graft in the immediate postoperative period showing small crescentic peritransplant collections, clinically insignificant.
Conclusion

Triplex US is the method of choice in the postoperative period and long term follow up of renal transplants.

Familiarity with normal renal transplant anatomy and common complications will allow rapid and accurate diagnosis.

Personal information

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