Ultrasonographic Evaluation of the Renal Transplant

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KEYWORDS

• Ultrasonography • Renal transplant • Vascular • Doppler • Renal artery stenosis • Rejection

KEY POINTS

- Categorization of transplant complications by time of occurrence is helpful for formulating appropriate differential diagnoses.
- Renal transplant complications may arise in the perinephric space, renal vasculature, renal parenchyma or collecting system.
- The combination of gray-scale ultrasound with color and spectral Doppler is necessary for complete renal transplant evaluation.

INTRODUCTION

Renal transplantation is a mainstay treatment of end-stage renal disease. Ultrasonography is an excellent tool for transplant evaluation in the immediate postoperative period and for long-term follow-up. Advances in imaging, surgical technique, and medical management have increased graft survival rates. Complications can be categorized based on timing of occurrence, but can also be divided by location into perinephric, vascular, parenchymal, and collecting system abnormalities (**Table 1**).[1] **Box 1** lists common indications for kidney transplant imaging.

SURGICAL TECHNIQUE

In adults, the transplant kidney is typically placed in an extraperitoneal location in either iliac fossa, usually the right because of the straighter course of the right iliac vein. The superficial location of the external iliac vessels facilitates surgical dissection and creation of vascular anastomoses. In deceased donor transplants, the donor renal artery is harvested with a small oval-shaped patch of aorta termed a Carrel patch, which is used for anastomosis to the external iliac artery. In living donor renal transplants, the main renal artery is typically harvested in isolation and anastomosed directly end-to-side with the external iliac artery or end-to-end with the internal iliac artery. An end-to-side anastomosis is made between the donor renal vein and the external iliac vein. A ureteroneocystostomy is created by implanting the donor ureter into the dome of the urinary bladder.

Multiple surgical variations exist; therefore, discussion with the transplant surgeon or correlation with the operative report is helpful. Common variations include intraperitoneal placement of the renal transplant (more common in children), ureteral implantation into an interposed bowel segment, and creation of a ureteroureterostomy

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Table 1
Time of occurrence of renal transplant complications

Immediate (<1 wk following transplantation)	Acute tubular necrosis Acute rejection Renal artery thrombosis Renal vein thrombosis Perinephric hematoma Graft infection and abscess Compartment syndrome
Early (1 wk to 1 mo following transplantation)	Acute rejection Urinary tract obstruction Urine leak Urinoma Renal vein thrombosis
Late (>1 mo following transplantation)	Chronic rejection Medication toxicity Ureteral stricture Vesicoureteral reflux Renal artery stenosis Arteriovenous fistula and pseudoaneurysm Lymphocele Seroma Renal masses and posttransplant lymphoproliferative disorder Renal calculi Medullary nephrocalcinosis
Occur at any time	Torsion of the transplant kidney Pyelonephritis Segmental infarct

Box 1
Indications for kidney transplant imaging

- Immediate postoperative evaluation
- Routine surveillance imaging
- Follow peritransplant collections
- Elevated or rising creatinine
- Pain in region of transplant
- Decreased urine output
- Fevers and chills
- Severe hypertension refractory to medical therapy
- Hypertension and unexplained graft dysfunction

or pyeloureterostomy. In pediatric deceased donors, both kidneys and the accompanying aorta and inferior vena cava can be transplanted into a single adult recipient.

NORMAL RENAL TRANSPLANT ULTRASONOGRAPHY FINDINGS

The normal transplant kidney demonstrates the same features as a normal native kidney. However, corticomedullary differentiation in a transplanted kidney is usually more pronounced, owing to its more superficial location. The ability to scan with a higher-frequency transducer also allows for better appreciation of the renal echotexture and shape of the individual cortical segments. Often the collecting system is slightly dilated because of the expected reflux at the ureterovesical anastomosis in addition to autonomic denervation, and typically is limited to the renal pelvis. The fluid in the renal pelvis allows visualization of the urothelium, which should be thin. After 2 months, the normal transplant kidney usually hypertrophies and can elongate by 2 to 3 cm.

On color Doppler imaging, arterial and venous flow should extend to within a few millimeters of the capsule throughout all renal segments, although this depends on depth of the transplant kidney, transducer frequency, and sensitivity of the color Doppler settings. Occasionally flow will appear to be decreased or absent in deeper portions of the kidney, which should prompt evaluation with power Doppler, as it is more sensitive than color Doppler.

Spectral Doppler interrogation of the arterial waveforms should show brisk systolic upstrokes. Intralobular or arcuate artery resistive indices (RIs) of greater than 0.80 are often used as a nonspecific parameter for transplant dysfunction.[2] Peak systolic velocity (PSV) of the main renal artery should be less than 250 to 300 cm/s. Normal triphasic high-resistance waveforms should be observed in the ipsilateral external iliac artery. The normal PSV ratio of the renal artery to the ipsilateral external iliac artery has been described to be less than 1.8 to 3.5.[3,4] The main renal vein should have monophasic to mildly pulsatile flow, depending on the cardiac status, with similar findings in the ipsilateral external iliac vein. Normal ultrasonography findings are shown in **Fig. 1**, and a summary of the technique is given in **Box 2**.

VASCULAR ABNORMALITIES

Renal Artery Stenosis

Vascular complications occur in fewer than 10% of renal transplants.[5] Renal artery stenosis (RAS) is