Pediatric Abdominal Organ Transplantation
Current Indications, Techniques, and Imaging Findings

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KEYWORDS

• Pediatric renal transplantation • Liver transplantation • Multivisceral transplantation
• Doppler ultrasound • Hepatic artery thrombosis • Renal artery stenosis • Intestinal failure

KEY POINTS

- Vascular complications in pediatric renal transplants, including renal artery thrombosis, renal vein thrombosis, and renal artery stenosis, remain the main cause for graft loss.
- Compared with adults, a higher rate of complications is seen with pediatric liver transplantation.
- Accurate and timely radiological diagnosis of transplant complications facilitates appropriate treatment and minimizes morbidity and mortality.
- Doppler ultrasound is the mainstay of imaging after transplantation.
- Computed tomography (CT) and CT angiography, MR imaging and magnetic resonance (MR) angiography, MR cholangiopancreatography, conventional angiography, and nuclear medicine imaging may be used for problem-solving in pediatric transplant patients.

RENAL TRANSPLANTATION
Introduction

End-stage renal disease (ESRD) affects pediatric patients of all ages, with an incidence of 14.1 cases/million in 2012.[1] The most common causes for pediatric ESRD in young children are renal dysplasia and congenital urinary tract obstruction/reflux nephropathy, whereas acquired glomerular disease, such as focal glomerular sclerosis, is more commonly seen in older pediatric patients. Treatment is usually sequential, initiated with hemodialysis and followed by peritoneal dialysis and renal transplant.[1,2] In recent years, renal transplant has become the optimal therapeutic option for pediatric patients with end-stage kidney disease, providing the most effective long-term renal replacement therapy, with the advantages of significantly improved survival as compared with long-term dialysis as well as a better growth potential and overall quality of life.[3–5] The main contraindications for renal transplantation include active or chronic sepsis, active malignancy, and ESRD from autoimmune disease with elevated levels of circulating antiglomerular basement membrane

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antibodies like Goodpasture disease and systemic lupus erythematosus.[6,7]

Normal Anatomy and Imaging Techniques

Ultrasound is the anatomic imaging modality of choice in renal transplant, providing a comprehensive assessment including gray-scale and color Doppler evaluation of the renal graft and spectral Doppler interrogation of the transplant vasculature. At the authors' institution, an initial baseline ultrasound examination is performed immediately after surgery (**Box 1**). Short-term follow-up sonographic evaluations are obtained as needed depending on clinical evolution and initial imaging findings, whereas long-term follow-up includes yearly ultrasound examinations.[8,9] Ultrasound also provides guidance for renal graft biopsies. Contrast-enhanced ultrasound using gas-filled microbubbles can assess graft microvascular perfusion and was found to have prognostic value for long-term kidney function in adults,[10,11] therefore, potentially representing a future imaging modality in pediatric renal transplantation patients as well.

Renal scintigraphy using Technetium mertiatide (99m Tc [MAG 3]) is currently the preferred functional imaging method of evaluating the transplanted kidney given its capability to assess the graft perfusion, parenchymal uptake, and excretion. For many years, renal scintigraphy was performed routinely for all pediatric patients immediately after transplant, but is now used as a problem-solving tool for suspected complications after surgery.

Cross-sectional imaging with computed tomography (CT) or magnetic resonance (MR) has limited indications in pediatric renal transplants and is primarily used for evaluating vascular complications after transplantation. CT is now infrequently used in children with renal grafts given concerns for radiation and the nephrotoxic potential of CT contrast. MR has the advantage of a nonradiating anatomic technique with excellent angiographic capabilities and essentially nonnephrotoxic contrast agents; however, the utilization is compromised by the need for sedation in young children, its high cost, and its limited availability. MR renography is emerging as a powerful functional imaging tool, potentially able to differentiate noninvasively acute rejection from acute tubular necrosis, currently diagnosed by renal biopsy.[12,13] Although this technique may have an important role in the future, to the authors' knowledge, no data are yet available for pediatric renal transplant recipients.

Box 1
Imaging techniques

Doppler ultrasound

- Gray-scale imaging of the renal transplant
- Color and spectral Doppler evaluation of renal inflow and outflow including all anastomoses and sampling of parenchymal arteries

Renal scintigraphy with 99m Tc (MAG 3)

- Evaluates graft perfusion, parenchymal uptake, and excretion

MR and CT

- MRA may be used in vascular complications such as renal artery stenosis if indicated, with time-of-flight technique or contrast-enhanced time-resolved MR angiogram
- CTA is infrequently used; in select cases it can be performed with thin collimation and bolus tracking on the abdominal aorta tailored to individual pediatric patients
- Maximum-intensity-projection images can be obtained with both modalities

Preoperative Assessment

Abdominal Doppler ultrasound is routinely performed during pretransplant assessment to evaluate the vascular anatomy, including the aorta, inferior vena cava (IVC), and common iliac vessels[14] (**Box 2**). Contrast-enhanced CT angiogram is indicated in pediatric patients on peritoneal dialysis, in whom the aorta and IVC are incompletely visualized and assessed by ultrasound as well as in those with prior invasive vascular procedures/long-standing central lines with vascular occlusion detected by ultrasound. A chest radiograph is obtained the day before surgery to screen for active infection.[6,7]

More comprehensive pretransplant imaging studies are reserved for pediatric patients with specific urinary abnormalities, such as neurogenic

Box 2
Preoperative imaging in renal transplantation

Routine

- Abdominal Doppler ultrasound of the aorta, IVC, and common iliac vessels
- Chest radiograph

Advanced imaging

- CTA
- Voiding cystourethrogram
- Urodynamic studies