CHAPTER 2.3 Urological surgical procedure and management of complications

Susanne Deininger[1, 2] & Steffen Rausch[1]

[1] Department of Urology and Andrology, Salzburg University Hospital, Paracelsus Medical University, Salzburg, Austria
[2] Department of Urology, University Hospital Tübingen, Eberhard Karls University, Tübingen, Germany.

ORCIDs:
Susanne Deininger: https://orcid.org/0000-0003-3541-6973
Steffen Rausch: https://orcid.org/0000-0002-6398-8701

1 Urological evaluation of kidney transplant recipients and management of underlying urinary tract anomalies

Congenital kidney anomalies account for 42% of end-stage kidney disease in paediatric patients, making them the leading cause [1]. Therefore, a careful preoperative workup of the anatomical and physiological conditions of the urinary tract is essential. A detailed patient history, including a voiding diary if diuresis is still present, physical examination, and ultrasound are basic investigations. If necessary, these may be followed by urodynamics, voiding cystourethrogram, or cystoscopy [2]. Successful kidney transplantation (KTx) has been reported in cases of bladder dysfunction [3]. Secondary small-capacity bladders may regain volume after transplantation and with increased urine output [4].

KTx in cases of neurogenic bladder can be successful with the use of anticholinergics, and intermittent sterile catheterisation [2]. In cases of very small bladder volume, bladder augmentation can be performed using native dilated ureters or bowel segments. In addition, KTx may be considered in the presence of an ileal conduit or Mitrofanoff stoma. Timing is critical: bladder augmentation should be performed at least 3 months before transplantation or after transplantation (while the patient is on ongoing immunosuppression) [4].

2 Urological surgical technique

In some cases, it may be necessary to remove the native kidneys of paediatric patients prior to KTx (massive proteinuria, polyuria, refractory hypertension,

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recurrent urinary tract infection (UTI), malignancy or space-limiting cystic kidney disease [2]). Nephrectomy can be performed either simultaneously with the kidney transplantation or in a staged approach, with the subsequent lack of bladder filling potentially reducing bladder volume. For KTx itself, the organ is usually placed intraperitoneally in children under 10 kg. Depending on the source, kidney transplantation can be performed extraperitoneally in patients weighing between 8 and 15 kg [2].

After graft placement, the ureteroneocystostomy (UCN) is performed. Several points are important here: while the perfusion of the distal ureter should not be compromised, unobstructed urine flow from the ureter to the bladder is also crucial, as is the formation of an anti-reflux mechanism. The use of anti-reflux techniques in ureteroneocystostomy (UNC) was first described by V. Politano in the 1950s. Since then, this technique has been modified several times, and other techniques have been developed. The Politano-Leadbetter (PL) technique involves the following steps: an anterior cystostomy is performed to create an intravesical submucosal tunnel (2–3 cm). The new ureter is then introduced through this tunnel and sutured in place [5, 6]. In contrast, the Lich-Gregoir (LG) technique uses an extravesical approach. A 4 cm incision is made in the bladder wall, the ureter is sutured to the bladder mucosa, and the muscularis layer is then closed over the ureter [6]. In contrast, the Woodruff technique also involves an extravesical bladder incision, but unlike the Lich-Gregoir technique, the muscularis is not closed after the spatulated ureter is implanted into the bladder mucosa [7]. Several studies and meta-analyses have shown that the LG technique results in significantly lower rates of urological complications such as urinary leakage, uretero-vesical junction obstruction, and haematuria compared to the PL technique in adult patients [6, 8].

For paediatric patients, the optimal technique remains unclear. Anti-reflux techniques may increase the risk of UVJO, and Ranchin et al. demonstrated a VUR incidence of up to 58% in paediatric patients despite the use of anti-reflux techniques [9]. Furthermore, VUR remains asymptomatic in most organ recipients. The perioperative placement of a double-J ureteral stent is controversial in paediatric KTx: while the risk of urological complications is reduced [10], the risk of BK polyoma viremia and UTIs seems to be increased [11].

3 Management of urological complications in kidney transplant recipients

Ureteral stricture

Ureteral strictures occur in about 8% of children after KT. It usually manifests within the first 100 days after KTx and may be caused by ureteral ischaemia due to loss of distal perfusion from graft explantation, pre-existing anatomical anomalies (i.e. posterior urethral valves [12]), haematoma, lymphocele, stones, tumours, or scarring [13]. Initial treatment typically involves placement of a ureteral stent or nephrostomy, followed by further definitive operative treatment (endoscopic or open/laparoscopic ureteral reimplantation, or Psoas- or Boari hitch technique). Endoscopic options include laser or cold incision and/or balloon dilation followed by double-J stent placement.

Christman et al. (2012) treated 17 paediatric patients with primary obstructive megaureter using retrograde balloon dilatation (for strictures < 2 cm) or laser incision combined with balloon dilatation (for strictures > 2 cm), achieving resolution of obstruction in all cases. These techniques can also be effective in more proximal strictures [14–17]. If the retrograde approach is difficult, percutaneous access with dilatation can also be successful in such cases: Bachtel et al. reported a 75% success rate using antegrade balloon or Amplatz sequential dilatation for early postoperative strictures (< 6 months post-transplant) in paediatric patients. However, this technique was never successful in strictures older than one year [12].

Vesicoureteral reflux

The incidence of vesicoureteral reflux (VUR) after kidney transplantation varies from 10.5% to 86% depending on the implantation technique, with deceased donor organs having a higher risk than living donor organs [18, 19]. However, some studies suggest that VUR does not appear to adversely affect bacteriuria, renal function, or graft survival [20]. Nevertheless, VUR can cause complications that may initially go unnoticed: dimercaptosuccinic acid (DMSA) scans of paediatric KTx with VUR and recurrent UTI revealed that 69% had renal scarring [21]. Active treatment may be required in such cases. Similar to VUR in the native kidney, antibiotic prophylaxis may reduce the frequency of infections in cases of recurrent UTIs [22]. Injecting a bulking agent such as dextranomer/hyaluronic acid copolymer (Dx/HA) beneath the ureteral orifice or in the ureteral tunnel can effectively treat urinary reflux in certain cases. In paediatric patients, the injection has been well studied: a single injection is usually sufficient,

with only 3% experiencing febrile urinary tract infections over time [23]. The use of Dx/HA has also been studied in KTx patients with VUR. While Pichler et al. [24] observed a significant reduction in UTI frequency in adult kidney transplant recipients with VUR following Dx/HA injection, Wu et al. reported a success rate of only 22% for Dx/HA in paediatric patients with VUR post-transplant [22]. In cases of renal dysfunction, recurrent infection and failed endoscopic therapy, anti-reflux techniques such as ureteral reimplantation may be required.

Urolithiasis

Following KTx, paediatric patients may develop urinary stones: according to Khositseth et al., 5% of paediatric KTx patients developed urinary stones within the first 19 ± 22 months post-transplant [25]. The most common stone compositions were calcium phosphate and calcium oxalate, mixed calcium phosphate and oxalate, and struvite. Risk factors for stone formation in KTx patients include certain suture techniques, recurrent UTIs, urinary obstruction [25], and comorbidities associated with chronic kidney disease, such as hyperparathyroidism, hypercalciuria, hypocitraturia, or hypophosphatemia [26, 27]. Due to renal denervation during explantation, stone passage may sometimes be asymptomatic. For definitive stone management, endoscopic therapy with antegrade or retrograde flexible ureteroscopy appears to be a safe and successful approach [28, 29]. Percutaneous nephrolithotomy (PCNL) or mini-PCNL can be easily carried out for larger calculi due to the location of the kidney in the iliac fossa In the paediatric cohort studied by Khositseth et al. [25], spontaneous stone passage occurred in only 20% of the patients. The remaining patients required surgical intervention, with 55% undergoing retrograde endoscopic procedures, and the remainder treated by open or laparoscopic surgery. Boissier et al. (2023) reported in a meta-analysis that in adult KTx patients, the stone-free rates (SFR) at 3 months were 96% with open surgery, 95% with antegrade ureteroscopy, 86% with percutaneous nephrolithotomy (PNL), 81% with retrograde ureteroscopy, 75% with shock wave lithotripsy (SWL), and 62% with medical treatment.

Urinoma

Urinomas occur in less than 10% of kidney transplant patients, usually within the first 3 months after transplantation [30, 31]. All parts of the urinary tract can be affected, and management with nephrostomy or antegrade stenting is the treatment of choice for symptomatic urinomas, as the retrograde approach can

be challenging. Larger fluid collections may also require percutaneous drainage under CT or ultrasound guidance may also be necessary [32]. A transurethral catheter may be placed to minimise reflux across the double-J stent [33, 34]. Surgical revision, such as ureteral reimplantation or lesion repair, is rarely required [35].

Lymphocele

Lymphocele formation after kidney transplantation is a common complication, occurring in up to 22% of cases [11], due to dissection of donor or recipient lymphatic vessels during surgery. It typically occurs within the first week after KT. Risk factors include immunosuppression with sirolimus, older age, higher BMI, number of transplantations and surgical technique [11, 36]. Most cases are asymptomatic, but some patients require intervention due to pain or graft dysfunction. Patients requiring treatment for lymphoceles are at higher risk of graft rejection or delayed function [37]. Gander et al. showed that percutaneous drainage, with or without sclerotherapy (especially with povidone-iodine), is a safe approach for symptomatic lymphoceles in paediatric patients [38]. If minimally invasive therapy fails, open or laparoscopic lymphocele fenestration is used [39].

Recurrent urinary tract infections

Urinary tract infections (UTIs) are the most common type of infection after transplantation, occurring in up to 47% of cases. The risk of UTI is particularly high in the first month post-transplant [40]. Risk factors for UTI post-KTx include female sex, race, immunosuppression (i.e. azathioprine or cyclosporin A) [41], history of acute rejection, cytomegalovirus infection, UVJO [42], re-transplantation [43], polycystic kidney disease [44], diabetes mellitus [45], VUR in the native kidneys, male sex (2–5 years of age) and female sex (≤ 1 year of age) [41]. Prophylactic antibiotics are recommended for acute cases and primary recurrences, but it is also important to evaluate for potential allograft pathology. The risk of graft loss is significantly increased in all children after early UTI (< 6 months post-transplant; $P < 0.001$), but not after late UTI (≥ 6 months post-transplant; $P = 0.27$) [41].

The most common pathogens in paediatric organ recipients are E. coli, Pseudomonas aeruginosa, Klebsiella, and Enterococci [46]. Candida infections are also possible, and some centres recommend prophylactic antifungal treatment during antibiotic therapy. Paediatric patients typically receive prophylactic antibiotics for the first 3–6 months after KT, including prophylaxis for Pneumo-

cystis jirovecii, although this practice is controversial, and some studies have found that it only exacerbates resistance patterns in UTIs [46, 47].

Any underlying anatomical or functional problems should be addressed. Residual urine should be managed with intermittent sterile self-catheterisation. Behavioural measures include high oral fluid intake, hygienic practices – especially for sexually active women – and management of constipation [46].

Additional measures, such as herbal therapies (e.g., Canephron® or Angocin®, Utribro®), cranberry products, D-mannose, urinary acidification, and vaccination (e.g., Uro-Vaxom®, StroVac®), have not been specifically studied in paediatric kidney transplant patients, but can be discussed.

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