Appendicocecal Loop Urinary Diversion in a Transplant Kidney: Case Report, Literature Review

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ABSTRACT

Urinary diversion in renal transplant patients can take a variety of forms – bladder augmentation, continent cutaneous pouch, or intestinal conduits, to name a few. Herein, we present a unique case of an appendicocecal urinary diversion in a patient with history of end stage renal disease, pelvic radiation, and complex surgical history who underwent deceased-donor renal transplantation. During the renal transplant, the transplant ureterovesical anastomosis could not be performed due to inherent anatomical hindrances. A temporary modified cutaneous ureterostomy using a single-J stent was therefore used for drainage of the transplant kidney. Given that the cutaneous ureterostomy was not a durable, long-term option, we sought to develop a creative surgical solution. This report presents a unique case of urinary diversion post renal transplant and reviews the literature of renal transplantation in patients with anatomical abnormalities.

KEYWORDS: renal transplant, urinary diversion, ureter, appendicocecal loop

INTRODUCTION

In the United States, more than 500,000 adults live with end stage renal disease (ESRD).[1] Renal allograft transplantation is the gold standard therapeutic option for these patients. Approximately 6% of patients undergoing renal transplant have lower urinary tract (LUT) abnormalities, and 15% of patients have secondary LUT anatomical abnormalities.[2] The native bladders in these patients are often unsuitable for transplantation, due to loss of detrusor muscle and bladder compliance from infrequent bladder cycling and underlying medical comorbidities, resulting in a unique operative challenge for renal transplant surgeons. Given that graft survival can be compromised by a high-pressure non-compliant bladder, urinary diversion or augmentation cystoplasty either prior to or following transplantation, are methods to ensure long-term transplant success.[3-5] In genitourinary reconstructive surgery, the appendix has been used for over 100 years as an interposing segment.[6] In pediatric renal transplantation specifically, the appendix has been used as a ureteral substitute in patients with extended ureteral strictures.[7,8]

We present here a unique case of a 71-year-old male patient with ESRD and history of pelvic radiation with atrophic bladder who underwent renal transplantation. Due to lack of an adequate urinary reservoir at the time of transplant, a cutaneous ureterostomy was initially created. A urinary diversion in the form of an appendicocecal loop was subsequently created to overcome a shortened allograft ureter and an end-stage bladder. This, to our knowledge, is the first record of such a procedure.

PATIENT BACKGROUND AND INITIAL RENAL TRANSPLANT

The patient was a 71-year-old man with past medical history of left colon cancer status post radiation and colectomy with end colostomy, gastroesophageal reflux diseases, restless leg syndrome, deep vein thrombosis/pulmonary embolus, ESRD who was evaluated for renal transplantation. At the time of his deceased-donor kidney transplantation (DDKT), the patient's native non-functioning bladder was noted to be contracted with a 20-cc capacity and obliteration of bilateral native distal ureteral lumina. These findings made for an unsuccessful attempt at ureteroureteral anastomosis. The transplant ureter, therefore, was secured to the posterior rectus fascia and a single-J stent was placed percutaneously via the transplant ureter into the transplant renal pelvis. The stent was secured to the skin and an ostomy appliance was placed over this modified cutaneous ureterostomy. The tract epithelialized post-operatively, but the patient had delayed graft function which is defined as increase in creatinine within 48 hours after transplant or acute kidney injury (AKI) necessitating dialysis within one week after transplant.[9] After studies suggesting post-obstructive AKI and acute tubular necrosis, the patient underwent placement of percutaneous nephrostomy tube into the transplant kidney. He improved gradually post-operatively and recovered urine output. His creatinine stabilized several weeks later to 3.1 mg/dL.

Four weeks post-operatively, the patient presented to the emergency room with decreased urine output, which raised concern for ischemia of the ureterostomy, urinary tract infection, and dehydration. Physical exam revealed drainage of urine as expected from the ureterostomy. The patient underwent percutaneous nephrostomy exchange and received IV antibiotics and fluids for the infection. Renal

ultrasound demonstrated preserved vascular flow, trace perinephric fluid, and no significant hydronephrosis. The patient was thereafter discharged home.

The patient was followed closely in the transplant clinic, by both nephrology and urology. His creatinine continued to improve, stabilizing at 2.15 mg/dL, and urine output remained consistent. Once he was medically optimized, the patient was recommended for exploratory laparotomy, ureterostomy with possible buccal mucosal graft, possible ileal loop creation, and all indicated procedures.

APPENDICOCECAL LOOP URINARY DIVERSION

The patient underwent an exploratory laparotomy that revealed extensive intraabdominal adhesions. After the adhesions were taken down carefully, the right colon was identified from the ileocecal junction to the hepatic flexure. The cecum was identified, along with an attached long appendix, in the right lower quadrant with robust mesenteric blood supply. The transplant kidney was palpable in the extraperitoneal space, just inferolateral to the cecum. The transplant ureter was identified by following the ureteral stent from the cutaneous ureterostomy to the posterior fascia. There was limited length of the transplant ureter. Given the proximity of the ureter to the distal aspect of the appendix, the decision was made to use to appendix and cecum for the ureteral anastomosis and the urinary conduit, respectively.

Transplant ureterolysis was performed to mobilize the ureter off the posterior fascia. The distal end of the ureter was excised sharply, and the ureter was spatulated posteriorly approximately 1.5 cm with Potts' scissors. Next, appendiceal and proximal cecal mesenteric blood supply was inspected and confirmed to be appropriate with transillumination. A mesenteric window in between the vessels was made using a right-angle clamp. A vessel loop was passed through the mesenteric window, after which the window was carefully widened to fit the stapler. The proximal cecum with the attached appendix was divided just inferior to the ileocecal valve using an endoGIA® 80 mm stapler load. The staple line was inspected and found to be hemostatic on both sides.

To construct the appendicocecal conduit (**Figure 1**), the distal end of the cecum was sharply excised with scissors and the distal end of the appendix was sharply excised with scissors. After covering the abdominal opening with towels, the conduit was irrigated with warmed saline to remove the succus. The appendix was spatulated posteriorly approximately 1.5 cm with Potts' scissors. A single J 6x26 stent was passed through the conduit. A sensor wire was then passed through the stent to straighten it and the wire was passed through the transplant ureter to the renal pelvis of the transplant kidney. The stent was passed over the wire and positioned, after which the wire was removed. The stent was secured to the cecal mucosa of the conduit with a 3-0

Figure 1. View of the appendicocecal conduit and surrounding anatomy. [**A**] Prior transplant ureterostomy at posterior fascia; [**B**] Final ureteral stent; [**C**] Appendicoureteral anastomosis; [**D**] Appendicocecal conduit; [**E**] Cecal urostomy.

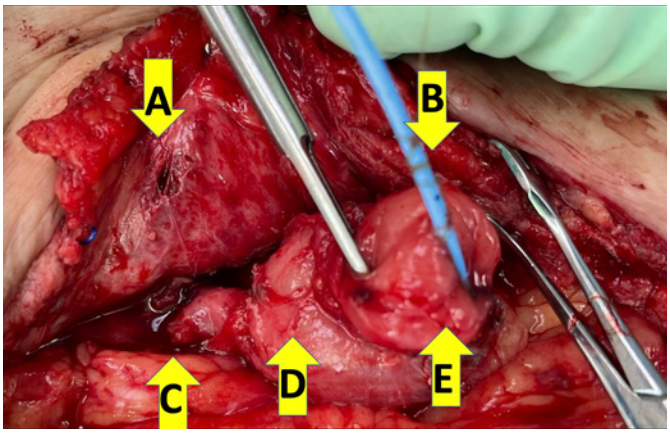
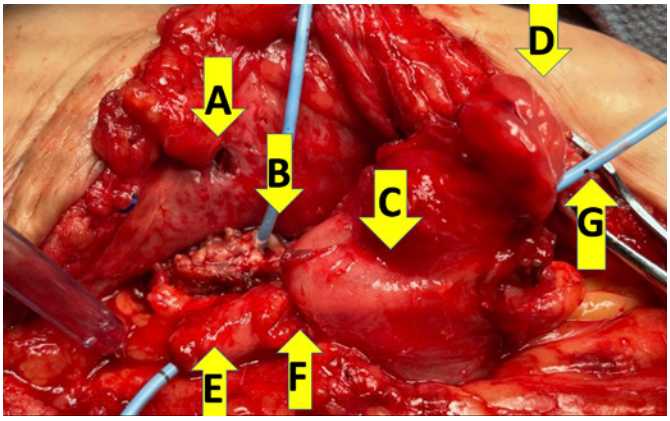


Figure 2. Closer view of the appendicocecal conduit with visible appendicocecal junction and the final ureteral stent in the appendix. **[A]** Prior transplant ureterostomy at posterior fascia; [**B**] Transplant ureter with previously placed ureteral stent; [**C**] Cecal conduit; [**D**] Cecal urostomy; [**E**] Appendix with final ureteral stent; [**F**] Appendicocecal junction; [**G**] Final ureteral stent.



chromic simple interrupted suture. Next, we anastomosed the distal end of the appendix to the transplant ureter using 5-0 PDS sutures in an interrupted fashion from the apex on each side, taking care to avoid the stent (**Figure 2**). The site of the marked right lower quadrant ostomy was incised with a #15 blade to create a circular opening for the urostomy. We made a cruciate fascial incision wide enough to pass two fingers through. A Babcock clamp was passed through the fascial opening and into the abdomen. The distal end of the appendicocecal conduit was grasped and pulled through the abdominal incision with the stent in place. The urostomy was matured to the skin with 2-0 Vicryl sutures in four quadrants in a Brooke fashion and additional 4-0 chromic interrupted sutures were placed through the mucosa and dermis

to create a protuberant viable rosebud urostomy. The stent was flushed, and urine output was noted from the conduit. The abdomen was closed in the standard fashion. A stomal appliance was placed around the urostomy and the ureteral stent was placed into the urostomy appliance.

POST-OPERATIVE COURSE

The patient progressed well post-operatively and had consistent return of bowel function 6 days after surgery. He was restarted on immunosuppression and had excellent urine output throughout his recovery. The patient's creatinine improved from his pre-operative baseline of 2.15 mg/dL to 1.7 mg/dL. Once he was stable from a medical and surgical standpoint, he was discharged to a rehabilitation facility for short-term physical therapy. His capped transplant percutaneous nephrostomy was removed 4 weeks later post-operatively and his ureteral stent was removed 6 weeks post-operatively. The patient thereafter continued to have stable graft function. There were no reported anatomic complications in this time.

REVIEW OF LITERATURE AND DISCUSSION

Patients with anatomically abnormal or dysfunctional lower urinary tracts (LUT) pose distinct challenges for renal transplant and reconstructive surgeons. Implantation of the transplant ureter into a non-compliant bladder should be avoided due to the significant risk of graft loss due to high-pressure urinary storage. In transplant patients with end-stage bladders, urinary diversion options include bladder augmentation, continent cutaneous pouches and intestinal conduits.[10,11] All these techniques have unique advantages and disadvantages that should be considered on a case-by-case basis depending on patient factors. Additionally, timing of a urinary diversion procedure, prior to, during, or after transplant, is also important to graft success. In transplant patients, a key aspect of pre-operative evaluation involves determining which patients will need staged versus simultaneous urinary reconstruction to achieve a structurally and functionally unobstructed, low-pressure urinary tract. This involves a thorough history to establish a timeline of LUT dysfunction in relation to development of ESRD. Furthermore, oliguria and eventual anuria in ESRD can result in a poorly compliant bladder due to the absence of routine autonomous bladder cycling with storage and emptying. Extensive urodynamic studies in patients who have undergone renal transplant defined inadequate bladder cycling as less than 300 mL urine cycled daily.[12] It is also essential to distinguish defunctionalized bladders with recoverable function from those with end-stage bladders due to pathologic contracture from extensive fibrosis.

In addition to bladder function, reflux of urine into the upper tracts is also important to consider, voiding cystourethrogram (VCUG), more commonly performed in the pediatric pre-transplant population, has been suggested as part of the standard workup for adult transplant candidates. The high likelihood (85.3–97.5%) of finding clinically insignificant reflux has eschewed the cost-effectiveness of VCUG for general transplant candidates.[13,14] However in patients with evidence of end-stage bladders and LUT abnormalities, VCUG and urodynamics demonstrated abnormal findings in 45% of patients.[12]

Lastly, a patient compliance assessment is key to ensuring transplant success in the setting of a urinary diversion. The transplant team must ensure patients have the education and capability to manage their diverted urinary systems. Improper or inadequate management of ostomy drainage or intermittent catheterizations can result in a variety of complications ranging from UTIs to graft failure, which can cause significant morbidity and mortality.[15]

One of the main urologic considerations in renal transplant is the transition from upper to lower urinary tract. In patients with normal anatomy, the donor ureter is anastomosed to the native bladder via a ureteroneocystotomy. In our patient, the bladder was contracted and retropubic, making it unfavorable and difficult to access for transplant ureter implantation. We therefore anastomosed the transplant ureter to the ipsilateral native ureter to provide the needed length to access the bladder. After completion of the ureteroureterostomy, no urine outflow from the native ureter into the bladder was observed. Furthermore, attempted intraoperative cystoscopy revealed obliterated bladder mucosa and no identifiable ureteral orifices. Due to a short transplant ureteral length, the ureter could only be brought up to the level of the anterior rectus fascia, where it was secured after placement of an externalized single J ureteral stent which served to drain the transplant kidney. While transplant cutaneous ureterostomy has fallen out of favor due to the high ureteral stricture rate, stomal stenosis, and infectious complications, at the initial time of surgery for our patient it was the only feasible option to pursue until the ischemic reperfusion injury of the allograft had resolved.[16] We also wanted to ensure that the patient passed the initial phases of recovery for the kidney transplant under standard immunosuppression protocols. As detailed above at the time of urinary diversion, patient-specific anatomic characteristics which included dense adhesions requiring extensive lysis, prior pelvic radiation, limited length of the transplant ureter, placement of the transplant kidney in the right lower quadrant, and an appendix with considerable length, led to the decision to use the appendix and cecum for the ureteral anastomosis and urinary conduit, respectively. Our unique use of an appendicocecal loop for urinary diversion in a transplant patient was accomplished by utilizing a key tenet of reconstructive urology: use viable, easily available, well-vascularized, and anatomically practical tissue in a tension-free manner that avoids any significant functional compromise

to donor and recipient sites. Use of the appendix has several benefits. The appendix harbors gut-associated lymphatic tissue (GALT) and commensal microbes, which could be protective against urinary tract infection.[17,19] It can also lower overall pressure in the conduit and provide a continence mechanism due to length.[18] Disadvantages include similar metabolic effects (dehydration and B12 malabsorption) and serum electrolyte abnormalities (hypokalemic, hyperchloremic, metabolic acidosis) as ileal and colonic conduits.

Although the literature on the subject is scant, long-term follow-up of renal transplant patients with appendicocecal junction urinary diversions may require surveillance for colonic and gastric metabolic effects due to inherent tissue types. The 5-year graft survival for any type of urinary diversion in renal transplantation is between 63% and 78%, amongst both pediatric and adult population, with limited data including long-term follow up at 15 years reporting 69% graft survival rate.[4,5] Additionally, while UTI is noted in approximately 65% of patients with urinary diversion, interestingly, no graft loss due to infection has been noted. Furthermore, graft survival has been reported to be comparable in patients with and without urinary diversions.[10,20-22] Chronic bacteriuria is frequently encountered in diverted patients, however no effect on transplant survival is noted despite the colonization.[16,23-25] This observation allowed for a shift towards less aggressive treatment of asymptomatic bacteriuria and greater acceptance of urinary tract reconstruction, which was historically viewed with caution due to the perceived risks of sepsis.[26] The risk of UTI (24%) and pyelonephritis (13%) in post-transplant patients with urinary diversions, in fact, remains reasonably low and has not proven to translate into worse patient outcomes.[2,27-29]

Complications specific to lower urinary tract reconstruction include stomal stenosis, prolapse of the conduit, fistula, dehiscence, urine leak, and metabolic abnormalities. Physical changes of the reconstructed urinary tract function are often symptomatic and early indicators for examination and even revision. These surgical complications can occur in the long- or short-term and should be monitored for regularly. Metabolic acidosis, a well-known phenomenon of ileal or colonic intestinal diversion due to excretion of bicarbonate and reabsorption of urinary solutes, such as chloride, by the mucosa, is more nuanced.[30-35] While transplant literature has focused on graft and infectious outcomes, the inherent incidence of metabolic derangements in the ESRD population may cause transplant teams to overlook the sequelae of reabsorption in transplant patients with reconstructed lower urinary tracts. Close follow up, electrolyte repletion, and urine and blood pH measurement are therefore important throughout the post-transplant course of these patients' lives. Monitoring both blood and urine pH allows to establish the type of acidemia in patients with metabolic acidosis. Lastly while the literature is limited on the incidence of secondary malignancy of intestinal segments after urinary diversion in the transplant population, transplant patients remain at an uncertain risk for malignancy given their immunocompromised state. While no consensus has been reached on surveillance, an appropriate level of concern should be maintained with interval endoscopy and surveillance imaging as clinically indicated.

CONCLUSION

ESRD is a life-limiting diagnosis that can be successfully mitigated by renal transplantation. While the main focus of transplant literature has been graft function and complications, it is important to consider urinary drainage and storage. Lower urinary tract evaluation prior to transplantation is essential to the longevity of the patient. In patients with dysfunctional or incompetent lower urinary tracts, reconstruction and augmentation restore functionality.

Our patient not only had insufficient bladder capacity, but also had multiple prior surgeries and pelvic radiation that precluded traditional reconstruction with an ileal or a colonic segment. We therefore had to develop a creative solution with accessible tissue to provide reliable egress for the urine from the transplant kidney. Given the location of the graft in the right lower quadrant, we identified adjacent the appendix and cecum as favorable tissues for incontinent diversion of urine. This is the first documented use of an appendicocecal conduit with a transplant kidney. The appendix segment served to augment the transplant ureter length and to provide a natural transition to a cecal reservoir and urostomy. The patient's transplant function improved significantly after definitive lower urinary tract reconstruction, and he has not had any major complications in the short term. While the long-term durability of our appendicocecal loop urinary diversion remains to be seen, we hope to offer an example of how reconstructive urologic techniques can supplement renal transplantation and provide lasting graft function for ESRD patients.

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