Case Series

Laparoscopic bilateral ileal ureter replacement for bilateral long-segment ureteral strictures: a case series of nine patients

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Background: The treatment of bilateral long segment ureteral strictures is challenging. Minimally invasive bilateral ileal ureter replacement has been presented with limited experience. This study presents the results of the largest known sample size of minimally invasive bilateral ileal ureter replacement as well as the very first experience of minimally invasive bilateral ileal ureter replacement.

Case Description: From April 2021 to October 2022, nine cases of laparoscopic bilateral ileal ureter replacement for bilateral long-segment ureteral strictures were recruited from the database of RECUTTER. Patient characteristics, perioperative data and follow-up outcomes were gathered retrospectively. Success was defined as relieved hydronephrosis and a stable renal function without serious complications. All the nine patients underwent the procedure successfully without serious complications or conversion. The median stricture length of bilateral ureters was 15 cm (range, 8–20). The median length of the ileum used was 25 cm (range, 25–30). The median operative time was 360 minutes (range, 270–400). The median estimated blood loss was 100 mL (range, 50–300). The median postoperative hospital stay was 14 days (range, 9–25). At a median follow-up of 9 months (range, 6–17), all patients maintained stable renal function and showed improvement in hydronephrosis. Four postoperative complications were recorded, including three urinary tract infections and one incomplete bowel obstruction. No serious postoperative complications occurred.

Conclusions: Laparoscopic bilateral ileal ureter replacement is safe and feasible for bilateral long-segment ureteral strictures. However, a large sample size with long-term follow-up is still needed to further demonstrate it as the preferred option.

Keywords: Ureteral stricture; ileum; ureter replacement; laparoscopic; case series

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Introduction

The treatment of bilateral long-segment ureteral stenosis is challenging. Although bilateral nephrostomy or Double-J stent placement can preserve renal function, frequent replacement of tubes and recurrent urinary tract infections affect the quality of life of patients (1,2). Autologous kidney transplantation is also an option. However, due to its technical complexity and potential complications, it is considered a remedial option after failure in ureteral

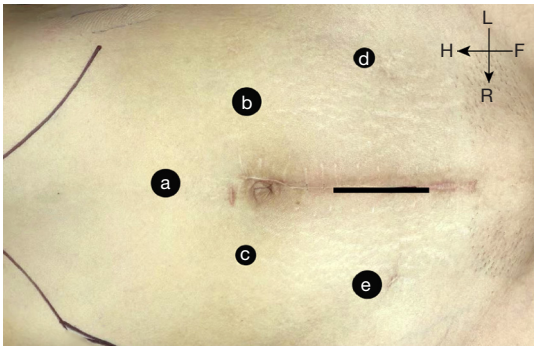

Figure 1 Trocar distribution in laparoscopic bilateral ileal ureter replacement. The laparoscopic lens is placed at point a. Two 12-mm trocars are placed at points b and e, and two 5-mm trocars are placed at points c and d. The black line in the lower abdomen represents the surgical incision for the ileum construction. H, head; L, left; R, right; F, foot.

repair (3). Conventional means of reconstruction become impotent in the treatment of bilateral long-segment strictures. Therefore, bilateral ileal ureter replacement (IUR) is considered the last resort.

The safety and efficacy of open bilateral IUR have been proven by studies with long-term follow-up (4). It provides good urinary drainage and effective preservation of renal function thus avoiding permanent nephrostomy and nephrectomy. However, the long surgical incision and large trauma required for open bilateral IUR limit its utilization. Unilateral laparoscopic and robotic IUR has been widely performed in the last decade (5,6). In recent years, bilateral IUR has also been successfully performed with less bleeding and faster postoperative recovery (7-11). Therefore, minimally invasive bilateral IUR seems to be a promising alternative to open bilateral IUR. However, the current reports on minimally invasive IUR are mainly case reports and small series with limited sample size and follow-up time. Moreover, given its complex surgical steps and physiological alterations, results of study with a larger sample size and longer term of follow-up are needed to demonstrate its safety and feasibility as the preferred option.

In this study, experiences and results of treating nine cases of bilateral long-segment ureteral structures with laparoscopic bilateral IUR are presented. To the best of our knowledge, this is currently the largest sample size reported for minimally invasive bilateral IUR. We present this case series in accordance with the AME Case Series reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-22-737/rc).

Highlight box

Key findings

- Laparoscopic bilateral ileal ureter replacement is safe and feasible for bilateral long-segment ureteral strictures.
- The nine patients in this series had a 100% success rate with no major complications.

What is known and what is new?

- It is known that open bilateral ileal ureter replacement is a good surgical option for long segment ureteral strictures with acceptable complications and laparoscopic and robotic approaches were also reported to be feasible.
- We report the largest known case series and the initial experience with laparoscopic bilateral ileal ureter replacement.

What is the implication, and what should change now?

- In selected patients, laparoscopic bilateral ileal ureter replacement may be more advantageous compared to open approach. More cases and longer follow-ups are needed.

Case presentation

Study population

From April 2021 to October 2022, nine consecutive cases of laparoscopic bilateral IUR from two different centers were retrospectively collected from RECUTTER database (http://pkufh.yorktal.com/). Patient characteristics, perioperative data, and follow-up data were gathered. Preoperative imaging evaluation including ultrasound, antegrade/retrograde urography, and computed tomography urography (CTU), is shown in *Figure 1*. Serum creatinine (Scr) and estimated glomerular filtration rate (eGFR) were used for preoperative kidney evaluation and documentation of postoperative surgical effectiveness. Success was defined as relieved hydronephrosis and a stable renal function without serious complications.

All procedures performed in this study were in accordance with the Declaration of Helsinki (as revised in 2013). Publication of this case report and accompanying images was waived from patient consent according to the Ethics Committee of Peking University First Hospital (approval No. 2020-SR-283).

Surgical technique

After general anesthesia, the patient was placed in the

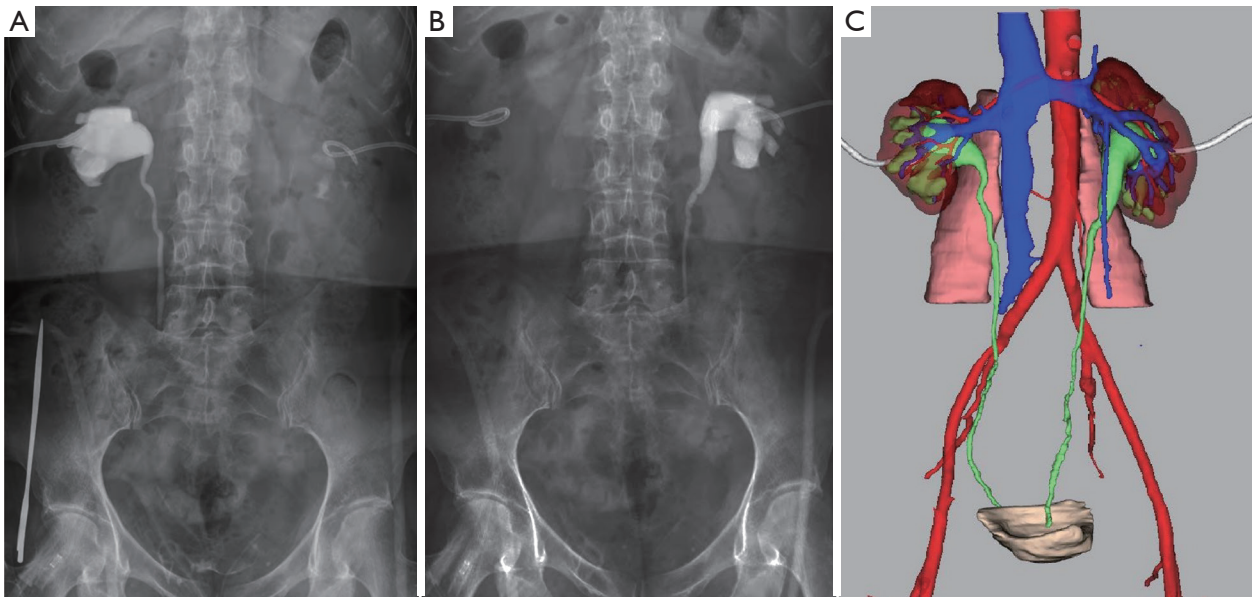

Figure 2 Bilateral antegrade urography (A and B) and 3D reconstruction model (C) of a female patient with bilateral lower ureteral stenosis.

truncal position with the leg elevated approximately 20–30°. The distribution of the trocar is shown in *Figure 2*. The procedures of open bilateral IUR have been described in our previous study (12). Laparoscopic IUR differed in some surgical steps. The bilaterally dilated ureters were first exposed and the junction between dilatation and stenosis was located (*Figure 3A*). Ureteral stumps of both sides were incised longitudinally for 2–3 cm for anastomosis with the ileal segment. Then, the top of the bladder was fully exposed. A graduated stent was used for intraoperative measurements. The distance between the stumps of the ureters and the total distance to the bladder were recorded (*Figure 3B*).

A 5-cm incision was made in the lower abdomen to prepare the ileal segment for IUR. An appropriate length of ileum was isolated at 15 cm from the ileocecal valve. Ileal continuity was restored by linear staplers (*Figure 3C*,*3D*). Subsequent reinforcement of the anastomotic margins and closure of the mesenteric defects were performed and the ileum was then placed back into the abdominal cavity. Then, the distal end of the ileal segment was folded and intermittently sutured into an anti-reflux nipple using absorbable thread (*Figure 3E*,*3F*, site C). Two Double-J stents (F7) were placed in the ileal segment. The first ureteral stent passed through the entire ileal segment. Then, a 1-cm incision was made in the ileal segment (*Figure 3F*, site B) according to the distance of the ureteral stumps. From the incision, the second Double-J stent was placed. These two Double-J stents were secured to the ileal segment using absorbable sutures (e.g., 4-0 Vicryl) to prevent displacement.

The ileal segment was placed into the abdominal cavity and the pneumoperitoneum was reconstructed. The bilateral ureter stumps and ileal segments were anastomosed separately. For reverse "7" anastomosis, the proximal end of the ileal segment and the left ureter stump were anastomosed end-to-end (*Figure 3G*, site A), and the right ureter stump was anastomosed end-to-side (*Figure 3H*, site B). The opposite was true for the "7" anastomosis. Then, the anti-reflux nipple was anastomosed to the bladder (*Figure 3I*). All sutures were performed consecutively using a mucosa-to-mucosa approach. Finally, the procedures were completed with the drainage tube in place.

Postoperative treatment and follow-up

Patients routinely received intravenous antibiotics for 3 days postoperatively. After the first flatus, the patients were given a liquid diet and gradually transited into a soft diet. Patients were followed at 1, 3, and 6 months postoperatively, and at least annually thereafter. At each visit, patients underwent blood tests, urinalysis, imaging evaluation, and clinical symptom assessment, respectively. Blood tests included blood gas analysis, Scr, eGFR, and electrolyte tests. Imaging

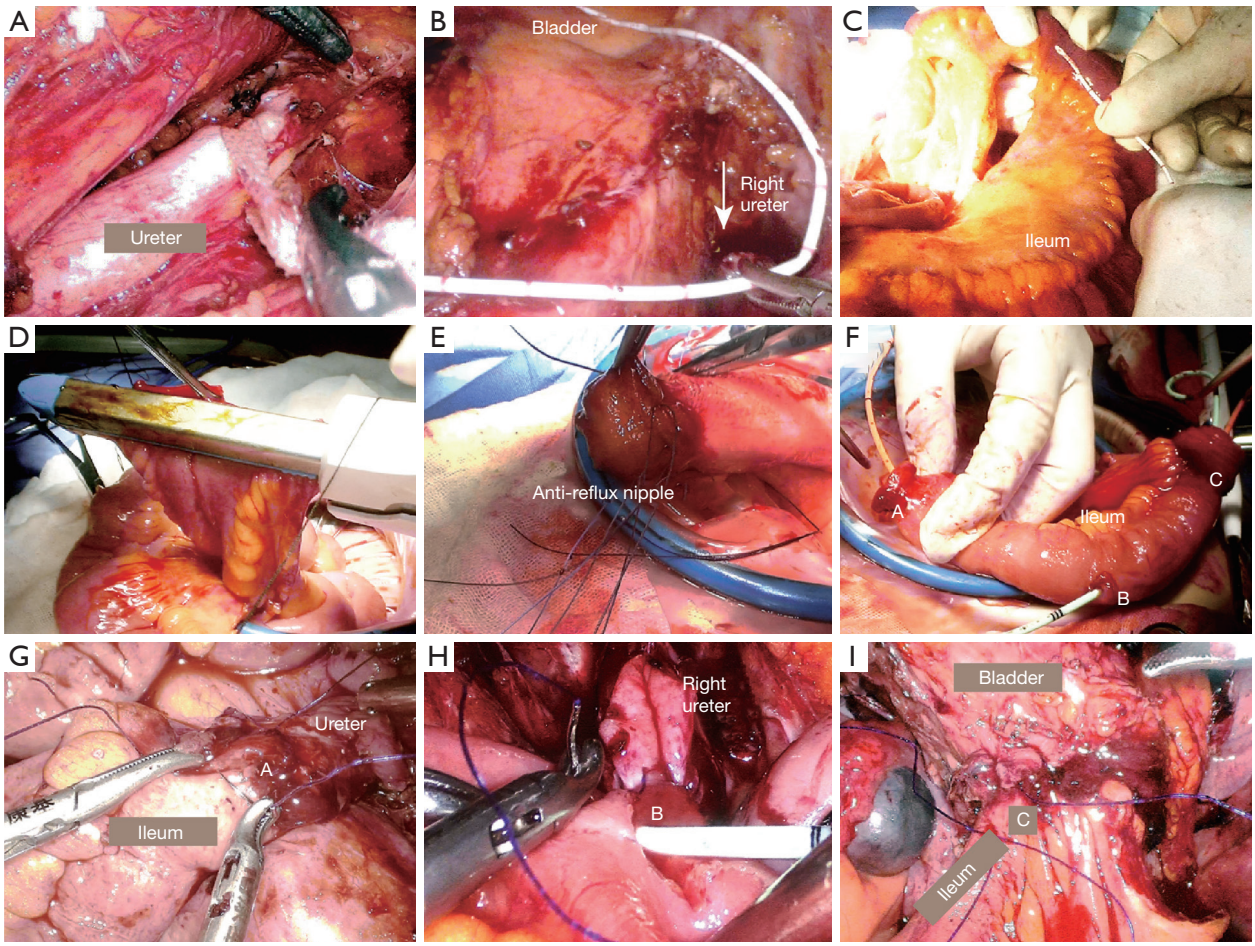

Figure 3 Surgical steps of laparoscopic bilateral ileal ureter replacement. (I) Ureteral stenosis segment visualization and measurement (A,B). (II) Harvest and extracorporeal construction of the ileal segment (C-F). (III) Anastomosis of ileal segment with bilateral ureteral stumps and bladder (G-I).

evaluation included ultrasound, antegrade urography, CTU, and cine magnetic resonance urography (MRU). Ureteral stents were removed 8 weeks postoperatively, after antegrade urography through nephrostomy tubes.

Statistical analysis

Continuous data were tested for normality using the Kolmogorov-Smirnov test. Paired samples *t*-test was used for normally distributed continuous data. The rank sum test was used for non-normal distributed data. All statistical analyses were performed on SPSS statistics© v.24 (IBM, Armonk, NY, USA), and a two-sided P<0.05 was defined as statistically significant.

Results

Patient characteristics are shown in *Table 1*. A total of 9 patients, all female, underwent laparoscopic bilateral IUR performed by the same experienced surgeon. The mean age was 44 years (range, 33–56). The mean BMI was 24.8 (range, 20.1–26.7) and the median duration of the disease was 53 months (range, 17–133). Etiology for the patients in our cohort included radiotherapy (7/9), iatrogenic injury (1/9) and ureteral polyps (1/9). The median length of the ureteral stricture was 15 cm (range, 8–20).

All patients underwent preoperative bilateral nephrostomy for adequate drainage of urine. After preoperative preparation, all patients underwent a reverse

Table 1 Characteristics of patients

N	Sex	Age, year	BMI, kg/m^2	Symptoms	Etiology	Duration of disease/month	Stricture length, cm, (L/R)	Degree of hydronephrosis, (L/R)	Scr, mg/dL	eGFR, mL/min/1.73 m^2
1	F	40	25.9	Flank pain, fever	Radiotherapy	53	20/20	Moderate/moderate	1.14	60.0
2	F	52	20.1	Flank pain	Bilateral ureteral lithotripsy	34	10/20	Moderate/severe	0.76	91.0
3	F	32	24.9	Flank pain	Bilateral multiple ureteral polyps	55	15/20	Moderate/severe	0.97	77.0
4	F	41	24.2	Flank pain, fever	Radiotherapy	55	17/15	Severe/severe	1.28	52.0
5	F	43	26.6	Flank pain	Radiotherapy	17	10/20	Moderate/severe	0.83	87.0
6	F	53	22.8	No	Radiotherapy	28	10/20	Moderate/moderate	0.93	70.6
7	F	33	26.5	Flank pain	Radiotherapy	33	15/10	Moderate/moderate	0.69	99.1
8	F	56	25.0	Flank pain, fever	Radiotherapy	133	10/8	Moderate/severe	1.23	66.0
9	F	49	26.6	No	Radiotherapy	71	12/10	Moderate/severe	1.30	52.3

BMI, body mass index; L/R, left/right; Scr, serum creatine; eGFR, estimated glomerular filtration rate.

Table 2 Perioperative data of patients

Variable	Value
Pre-operative Scr, mg/dL, mean ± SD	1.0±0.2
Pre-operative eGFR, mL/min, mean ± SD	72.8±17.0
Operative time, min, median (range)	360 (270–400)
Estimated blood loss, mL, median (range)	100 (50–300)
Length of ileum used, cm, mean ± SD	26.7±2.5
Hospital stays, days, median (range)	14 (9–25)
Perioperative complications, n (%)	4 (44.4)
Urinary tract infection	3 (33.3)
Small bowel obstruction	1 (11.1)

SD, standard deviation; Scr, serum creatine; eGFR, estimated glomerular filtration rate.

Table 3 Follow-up data of patients

Variable	Value
Follow-up, month, median [range]	9 [6–17]
Scr, mg/dL, mean ± SD	1.0±0.3
eGFR, mL/min, mean ± SD	70.1±21.7
Improvement of hydronephrosis, n (%)	9 (100)
Complications, n (%)	4 (44.4)
Urinary tract infection	4 (44.4)
Success rate, n (%)	9 (100)

SD, standard deviation; Scr, serum creatine; eGFR, estimated glomerular filtration rate.

"7" laparoscopic bilateral IUR. Anti-reflux nipple was routinely constructed. All procedures were completed with no conversion nor intraoperative complications.

Perioperative data are shown in *Table 2*. The median operative time was 360 min (range, 270–400), with a median estimated blood loss of 100 mL (range, 50–300). The median length of the ileum used was 26.7 cm (range, 25–30). The median postoperative hospital stay was 14 days (range, 9–25). Four minor complications (Clavien-Dindo grade IIa) occurred within 30 days postoperatively. Three patients were diagnosed with urinary tract infections presenting with bacteriuria and mild lower urinary tract symptoms, without fever or pyelonephritis. One patient endured incomplete small bowel obstruction, which resolved with conservative treatment.

The follow-up data are shown in *Table 3*. At a median follow-up time of 9 months (range, 6–17), all patients were symptomatically relieved except for one patient who had occasional discomfort in the surgical area. Renal function remained stable in all 9 patients. Paired analysis showed

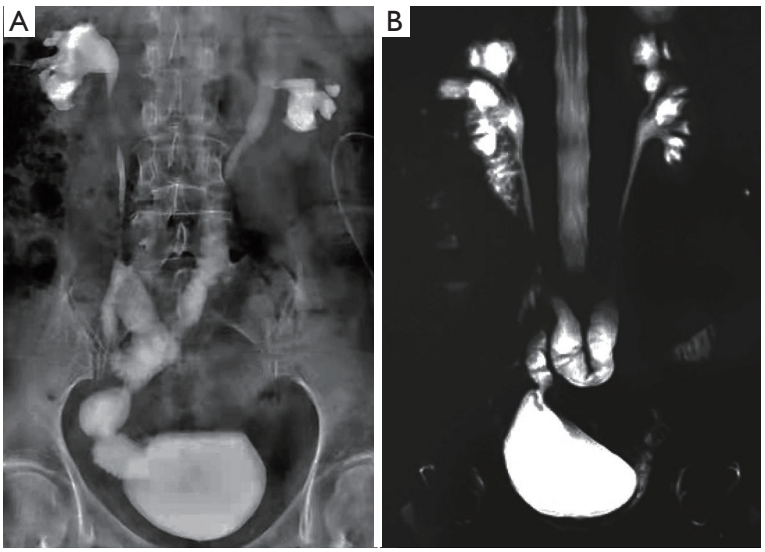

Figure 4 Images after laparoscopic bilateral ileal ureter replacement. Bilateral antegrade urography (A) and magnetic resonance urography (B).

no significant differences in Scr and eGFR preoperatively and 6 months postoperatively (P=0.969 and P=0.320, respectively). Imaging evaluation suggested good healing of the anastomosis with no stenosis or urinary extravasation (*Figure 4*). All patients had improved hydronephrosis. Four patients underwent urinary tract infections (Clavien-Dindo grade IIa) during the follow-up period, all of which improved after receiving oral antibiotics.

Discussion

Open IUR has been considered as a valuable ureteral alternative since its first introduction. It has good long-term outcomes, acceptable complications, and avoids the need for patients with complex ureteral strictures to undergo nephrectomy and autologous kidney transplantation (13,14). Open IUR was continuously developed: from unilateral IUR to bilateral IUR and then using a segment of ileum to replace both ureters. However, the disadvantages of open IUR are evident. Long surgical incisions, high morbidity, and prolonged hospital stays affecting the choice of patients and surgeons. With the development of minimally invasive surgical techniques, laparoscopic and robotic-assisted bilateral IUR were successfully performed with smaller incisions, less pain, and faster postoperative recovery (9,11). The good stability and stereoscopic view of the robotic surgical platform make bilateral IUR easier. However, laparoscopic bilateral IUR remains valuable as the robotic surgical platform mainly covers some high-volume centers and at a higher total cost.

Nowadays, the available reports of minimally invasive bilateral IUR are mainly case reports and small case series (*Table 4*). Large cohorts and long-term follow-up results are not yet available. Therefore, more evidence is needed to demonstrate its availability as the preferred option.

In this study, the largest known case series of minimally invasive bilateral IUR was reported. Radiotherapy was responsible for the largest morbidity of bilateral ureteral stricture in this series (7/9). As a common adjuvant therapy, radiotherapy kills tumor cells while inevitably causing radiological damage to normal tissues. The incidence of ureteral stenosis was reported to be 1.0–3.3%, which increases yearly after radiotherapy (15). Extensive fibrosis of the ureter and disruption of the blood supply result in a high risk of failure with conventional repair techniques. In this case, IUR is more actively considered as an alternate approach. The diseased ureter should be replaced by a non-radiologically damaged ileum segment to prevent poor healing and urinary extravasation.

Iatrogenic injury is the most common cause of ureteral strictures. Nevertheless, it does not account for a high percentage of patients with bilateral long-segment ureteral strictures requiring bilateral IUR. In most cases, the iatrogenic injury occurred in the unilateral ureter. Also, new repairing techniques such as lingual mucosal grafting and appendicular patching have provided urologists with more surgical options for iatrogenic injuries. However, when these procedures are not applicable, unilateral or bilateral

Table 4 Outcomes of the present study compared with other studies on minimally invasive bilateral IUR

Authors (year)	Patients, bi-/all (n)	Surgical platform	Reconstruction shape (n)	Anti-reflux technique (n)	Mean operative time (min)	Mean EBL in mL (range)	Hospital stays (d)	Renal function	Success rate	Major complications
Li *et al.* (2022) (8)	1/1	RA	"7"	Yes	252	100	NA	Stable	100%	No
Liang *et al.* (2021) (11)	2/2	LS	Reverse "7"	No	415	110	14.5	Stable	100%	No
Kochkin *et al.* (2022) (10)	8/40	LS	"7", reverse "7" and "U"	No	335 [150–680]	221 [50–400]	13.5 [10–35]	Stable	NA	1 renal vein injury and 2 intestinal injuries; 1 urine leakage, 1 ileus, 1 intestinal loop strangulation
Abhyankar *et al.* (2015) (9)	1/1	RA	Reverse "7"	No	NA	NA	NA	NA	100%	No
Ramalingam *et al.* (2013) (7)	1/1	LS	"U"	No	360	350	10	Stable	100%	No
Present study	9/9	LS	Reverse"7"	Yes	360 [270–400]	100 [50–300]	14 [9–25]	Stable	100%	No

IUR, ileal ureter replacement; EBL, estimated blood loss; RA, robotic-assisted; LS, laparoscopic.

IUR should be considered.

There are several key steps in our surgical procedures. First, mobilization of the ureter and localization of the stenotic segment while avoiding excessive disruption of the blood supply. Second, harvesting the ileum at the appropriate length and completing the ileum segment construction. Radiation-damaged intestines should be avoided. Usually, the damaged ileum is poorly peristaltic and shows different colors due to poor blood supply. Third, the construction of an anti-reflux nipple. Fourth, isoperistaltic anastomosis of the ileum "7" or reverse "7" to ureteral stumps and the bladder. For full-length defects without adequate ureteral stumps, a Y-shaped anastomosis is recommended. Fifth, all anastomoses should be completed in a tension- free, full-layer, watertight fashion to minimize the incidence of anastomotic fistula or stenosis.

The necessity of an anti-reflux design for IUR is still controversial. Some authors consider it unnecessary because the peristalsis of the ileum produces good anti-reflux effects when the ileum is longer than 15 cm (16). However, the long-term results of some studies do not seem to support this view. Bonfig *et al.* reported a significantly lower incidence of reflux in patients with an anti-reflux design compared to those without (13). A 25-year follow-up of 157 patients also showed that the incidence of urinary reflux was 100% in patients without an anti-reflux design and 16% in patients with an anti-reflux design (4). Thus, although peristalsis of the ileum does have an anti-reflux effect in the short term, its long-term results are not satisfactory. In addition, anti-reflux design was reported to reduce the risk of metabolic acidosis by reducing the duration of urine contact with the intestinal mucosa (17). Therefore, for the long-term benefit of patients, the routine use of anti-reflux designs is recommended.

The construction of the ileum segment in our series was performed extracorporeally. Although it requires an additional incision, extracorporeal construction of the ileum allows the surgeon to reinforce the ileal anastomosis and makes it easier to close the mesenteric defect the latter of which has been reported to reduce the incidence of internal herniation and small bowel obstruction (18). Complete intracorporeal reconstruction can be attempted, but it requires extensive experience and skilled surgical technique accumulated over a long period of time in open and minimally invasive surgery which is not easy for beginners.

Cine MRU was an important tool in our postoperative evaluation of the patient's urinary tract patency (*Figure 4B*). It is a non-radiation, non-invasive tool that clearly shows the morphology and peristalsis of ileal grafts (19). Also, mathematical calculations allow us to obtain the volume of urine excreted by each ileal peristaltic movement and thus to quantitatively assess the function of the ileal graft.

In the current series, all the nine patients showed good urinary tract patency, improvement in hydronephrosis and stable renal function, and meeting the definition of surgical success in the study. The success is most likely

the result of our screening criteria, surgical techniques, and post-operative management. The recommended contraindications for bilateral IUR include renal impairment (Scr >2 mg/dL), bladder dysfunction and outlet obstruction, and inflammatory bowel disease. The current widely accepted range of preoperative renal function was first proposed by Boxer in 1979. He advocated that patients preparing for IUR should have preoperative Scr less than 2 mg/dL (20). Poor preoperative renal function usually predicts a higher incidence of metabolic acidosis and further impairment of postoperative renal function. In the series of the current study, the mean preoperative Scr was 1.01 mg/dL. All patients had adequate urinary drainage and stable renal function after at least 3 months of nephrostomy. Patients who failed to meet the criteria were excluded.

The main complications of IUR include urinary tract infections, metabolic changes, mucus obstruction, urinary extravasation, and anastomotic stricture. Kocot *et al.* reported long-term complications in 157 patients including metabolic acidosis (19.5%), recurrent pyelonephritis (9.3%), mucus obstruction (2.5%), and anastomotic stricture (0.6%) (4). To prevent severe metabolic acidosis, patients in the series of this study received routine oral sodium bicarbonate postoperatively. Blood gas analysis was performed at each postoperative follow-up to monitor the patient's metabolic changes. At 1 year postoperatively, patients were instructed to gradually discontinue oral sodium bicarbonate. During a median follow-up of 9 months, no patient in this series developed severe metabolic acidosis or other severe complications (Clavien-Dindo grade III or higher) requiring re-intervention.

Inherent limitations of this study include its retrospective nature as well as the small size of the cohort. Evaluation of long-term metabolic complications, stone formation and long-term recurrence is difficult due to the short overall follow-up period. Robotic bilateral IUR as a promising procedure was also performed in our center. Due to the small number of cases and short follow-up, it was not included for comparison. In the future, comparative studies with larger sample sizes to further demonstrate the long-term safety and efficacy of this surgical method are needed.

Conclusions

Laparoscopic bilateral IUR is a safe and feasible technique for bilateral long-segment ureteral strictures. However, studies with larger sample size and a longer term of follow-up are still needed to further demonstrate it as the preferred option.

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Footnote

Reporting Checklist: The authors have completed the AME Case Series reporting checklists. Available at https://tau.amegroups.com/article/view/10.21037/tau-22-737/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-22-737/coif). XL serves as an unpaid editorial board member of *Translational Andrology and Urology* from May 2021 to April 2023. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the Declaration of Helsinki (as revised in 2013). Publication of this case report and accompanying images was waived from patient consent according to the Ethics Committee of Peking University First Hospital (approval No. 2020-SR-283).

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