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Original Article

Efficacy of ureterocalicostomy in treating secondary long-segment upper ureteral stricture

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Abstract: Objective: To evaluate the efficacy and safety of ureterocalicostomy for long-segment upper ureteral stricture. Methods: A total of 13 patients underwent ureterocalicostomy for long-segment upper ureteral stricture, and a long-term follow-up was carried out to observe postoperative results, complications and renal function at 6 months after surgery. Results: Among the 13 patients undergoing ureterocalicostomy, 12 achieved successful results with surgery. Nine of the 12 received open surgery and 3 patients received laparoscopic surgery. During the perioperative period, 3 patients developed fever while 2 patients had hematuria and irritation in lower urinary tract, and all improved after symptomatic treatment. The 12 patients with successful surgeries achieved remission of hydronephrosis without anastomotic stricture. At 6 months after surgery, the 12 patients had significantly decreased serum creatinine and cystatin C levels and markedly increased estimated glomerular filtration rate, as compared with those before surgery ($P<0.05$). Conclusion: Ureterocalicostomy is an effective, safe, optional treatment strategy for secondary long-segment upper ureteral stricture.

Keywords: Ureterocalicostomy, long-segment upper ureteral stricture, curative effect, safety

Introduction

Ureterostenosis, a common disease in urinary surgery, can lead to ureteropelvic junction obstruction, hydronephrosis, and even renal function impairments if left untreated [1]. It is often caused by ureteral injury, congenital anomalies, tumors and other factors, among which stricture of long-segment ureter is one special type [2-5]. Several different surgical procedures can be used to treat long-segment ureteric stricture [6-10]. However, for those with upper stricture who are not ideal candidates for ureteroscopy, common therapies are end-to-end ureteric anastomosis with excision of the stenosis part and pyeloureterostomy [5, 11]; for those with long ureteral defects or unexposed ureters, ileal ureter replacement is an optional treatment [12].

Ileal ureter replacement has the shortcomings of massive injury, and high requirements for patients' health status. Whether this method is suitable for children also needs to be considered. Based on an understanding of anatomy, physiology, pathology, principles of similar procedures and other relevant knowledge, we decided to use ureterocalicostomy to treat these patients, but its effects and safety are uncertain owning to the restricted number of operations. Therefore, we performed a retrospective analysis of 13 patients undergoing ureterocalicostomy to summarize its efficacy and safety.

Materials and methods

Clinical data

A total of 13 patients with ureteral stricture admitted to the Second Affiliated Hospital of Kunming Medical University from October 2007 to December 2017 were enrolled. Patient ages ranged between 2-71 years with a mean age of 49.2±27.9 years (ten males, three females). Among them, 7 patients had received laparoscopic surgery or end-to-end ureteric anastomosis, 1 patient had undergone ureteroscope holmium laser lithotripsy, 2 patients were diagnosed with ureteric stricture caused by genitourinary tuberculosis, and 1 patient was a 2.5-year-old child involved in a car accident 6 months ago.

The mean length of ureter stricture was 4.5±1.4 cm (3-7 cm), and the mean duration of the disease was 38.4 months (5-136 months). Eight cases had stricture on the left side and 5 cases on the right side. Thirteen patients showed hydronephrosis of different degrees and renal functions were all normal. After admission, all patients received B ultrasound, kidney ureter bladder (KUB) radiography, intravenous urography (IVU), and CT urography (CTU) if required, and confirmed by retrograde or anterograde urography. The length of urethral stricture or atresia, lesion characteristics and complications as well as analysis of renal pelvis and perinephric space were examined to evaluate the feasibility of ureterocalicostomy. This study was approved by the Ethics Committee of the Second Affiliated Hospital of Kunming Medical University and all written informed consents were provided.

Inclusion and exclusion criteria

Patients were included if they were diagnosed with ureteral stricture [1]; could tolerate surgery according to the evaluation of patients' general condition; and were aged between 2-71 years. Patients were excluded if they could not tolerate surgery due to a variety of reasons, combined with severe underlying diseases (e.g., cardiorespiratory dysfunction) or tumors.

Surgical methods

Both laparoscopic (3 cases) and open surgeries (10 cases) were used, and general anesthesia was performed on all patients. The surgical incision for open surgery was at the 11th intercostal space or the lower margin of the 12th rib by an extraperitoneal approach. Laparoscopic surgeries were operated by transabdominal approach. Kidneys and ureters were routinely exposed in open surgeries, and nutrient vessels of the ureter were reserved as much as possible during the procedure. Since this failed to isolate the renal pelvis of all the patients, ureterocalicostomy was then adopted. Exposure of the renal pedicle was not required in this surgery (the pedicle could not be exposed), but the inferior pole of the kidney needed to be clearly visible. The status of there being enough length of ureter and lower calyx to create an anastomosis was re-evaluated. If there was enough length, the lower calyces were dissected.

For those with a thinned cortex of the lower calyces, cross-incisions were made on the renal capsule and lower calyces were opened 1.0 cm in diameter. Circular incision of lower calyces and distal ureter (make a longitudinal incision of 1.0 cm at the distal end) were intermittently sutured with 4-0 Ethicon absorbable suture (VCP358H, Henan Didelung Medical Device Sales Co., Ltd; source: Johnson & Johnson, USA). It is important to note that the lower calyx mucosa should be well-aligned with the ureteral mucosa, and the renal parenchyma must not be aligned with the ureter. The reserved renal capsule and the ureteral adventitia were sutured with 4-6 stitches to wrap up the anastomosis.

For those with inferior pole located posteriorly, cross-incisions were made on the renal capsule, which was turned upward then. Conization was performed to remove the inferior pole of the kidney to make the diameter of anastomosis 1.0 cm. If hemorrhage took place, bleeding could be controlled by external compression by hands temporally. Bleeding points were transfixed. The reserved renal capsule and the mucosa of lower calyces was sutured (make a longitudinal incision of 1.0 cm at the distal end), covering the whole wound surface on renal parenchyma by the capsule. The whole covering was significantly crucial to avoid the postoperative recurrence of stricture. Lower calyces and ureter should be sutured in the same way. If possible, peripheral adipose tissue was used to cover anastomosis. The key points of laparoscopic surgeries were the same as with open surgeries. 6-F or 5-F (for the child) double indwelling J tubes were inserted in all patients. Postoperative treatment was given routinely.

Outcome measures

Main outcome measures: Operation time: The operation time from skin incision to the completion of suture was recorded and compared between the two groups.

Table 1. Comparison of general data

Item	Open surgery group (n=9)	Laparoscopic surgery group (n=3)	χ^2/t	P
Gender (male/female)	7:2	2:1	0.148	0.700
Age (year)	47.8±28.6	50.1±32.3	0.117	0.909
Stricture location (left/right)	7:2	2:1	0.148	0.700
Stricture length (cm)	4.3±1.5	4.7±1.7	0.389	0.705
Mean duration of disease (month)	38.98±8.98	39.21±9.21	0.038	0.970

Table 2. Comparison of surgical findings

Item	Open surgery group (n=9)	Laparoscopic surgery group (n=3)	t	P
Operation time (min)	198.5±56.3	111.6±25.3	2.526	0.030
Intraoperative blood loss (mL)	148.8±46.5	82.9±32.3	2.245	0.049
Postoperative hospital stay (d)	8.9±3.2	6.2±2.6	1.311	0.219

Intraoperative blood loss: The intraoperative blood loss was estimated and compared between the two groups.

Postoperative hospital stays: Days from impatient to discharge after the surgery were recorded and compared between the two groups.

Postoperative complications: Postoperative complications, such as systemic inflammation, hematuria, urinary tract infection, and poor healing after incision, were recorded and the incidence was compared between the two groups.

Secondary outcome measures: Long-term follow-up of all postoperative patients was performed. During the process, B-scan ultrasonography was undertaken to screen out ureteral stricture and urinary tract obstruction, and KUB plus IVU were applied to further clarify whether there was any obstruction, inadequate drainage or other situations [13]. Fasting blood (5 mL) was collected from antecubital vein in sterile vacuum tubes with ethylenediaminetetraacetic acid (1186d, Shenzhen Labware Co., Ltd) in the morning, and stored at 4°C for 15 minutes. Subsequently, the blood samples were centrifuged at 1106.8×g to collect serum, and serum creatinine and cystatin C levels were examined using the Beckman automatic biochemical analyzer (Beckman Coulter Inc., USA) within 4 hours. Moreover, glomerular filtration rate (GFR) was estimated by the means of Creatinine Equation issued by the Chronic Kidney Disease Epidemiology Collaboration [14]. See **Table 1** for details.

Statistical analyses

Data analysis was performed by SPSS 22.0. Continuous variables with normal distribution were expressed as mean ± standard deviation ($\bar{x}$ ± sd), and t-test was adopted for the comparison. P<0.05 was considered significant.

Results

General data

A total of 12 of 13 patients had successful surgeries, and the only patient with failed open surgery was forced to discontinue the operation because the inferior pole of the kidney, renal pelvis, and the upper segment of the ureter could not be exposed. As shown in **Table 1**, there was no significant difference in gender, age, or stricture location, between the two groups, suggesting the two groups were comparable (P>0.05).

Surgical findings

Three operations were completed laparoscopically. The operation time was 97-274 mins; the intraoperative blood loss was 60-170 mL; the length of postoperative hospital stay was 4 to 11 days. Further analysis revealed that operation time and blood loss in laparoscopic surgery were lower than those in open surgery (P<0.05), while there was no significant difference in the length of postoperative hospital stay between the two different methods (P>0.05). See **Table 2**.

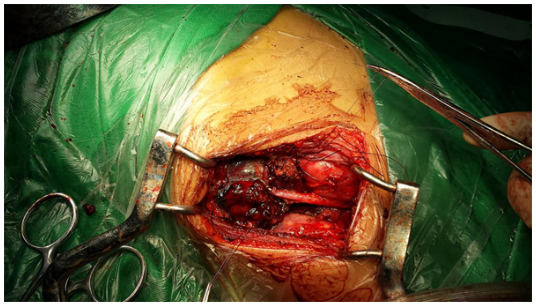

Figure 1. Ureterocalicostomy was performed on a 3-year-old boy who had renal rupture with ureteropelvic junction disruption 8 months before.

Postoperative reexamination

The mean duration of follow-up was 27 months (range 6 months-9 years). Postoperative imaging with KUB and IVU was undertaken in 12 patients. IVU results indicated enhanced kidney signs, improved excretion of contrast agents, and no anastomotic stenosis in these patients. See **Figures 1-4**.

Postoperative complications

Three patients developed fever postoperatively, one of whom had severe chills with high fever, so systematic infection was considered. Their conditions were under control after anti-infection treatment. Two patients developed hematuria, and irritation of lower urinary tract postoperatively, which were alleviated by symptomatic therapy. At 6 months after surgery, serum creatinine and cystatin C levels were decreased but eGFR was increased as compared to lab values before surgery (all $P<0.05$). See **Table 3**.

Discussion

Ureteral stricture is a common urological disease, and stricture is most common in the upper ureter. Upper ureteral stricture frequently occurs at the junction of kidney pelvis and ureter. Patients with ureteral stricture will develop back pain, urinary tract obstruction, and infection, even urinary tract empyema and renal function impairment. Ureteral obstruction is divided into primary obstruction and secondary obstruction according to etiology. Primary ureteral obstruction may be related to a congenital deformity in aberrant or accessory renal arteries. Secondary ureteral obstruction is

Figure 2. The 6-months postoperative KUB of a 3-year-old boy who had renal rupture with ureteropelvic junction disruption 8 months before. KUB: kidney ureter bladder.

mainly due to urinary tract infection, stones, trauma, foreign bodies, iatrogenic injury, ureteral surgery, and tumor. With the rapid development of diagnostic and treatment technologies, more patients are being diagnosed with ureteral stricture, and this is a great problem for urologists. Ureterocalicostomy has become one of the treatments for complicated obstruction of ureteropelvic junction or upper ureteral stricture that is unsuitable for anastomosis to the renal pelvis [15-18]. Upper ureteral stricture can be confirmed by CTU, magnetic resonance urography (MRU), IVU, or retrograde pyelography. Currently, there are many methods used to treat upper ureteral stricture, mainly including intracavitary minimally invasive treatment, ureteroplasty, and intracavitary minimally invasive treatment plus ureteroplasty. In addition, the treatment of upper ureteral stricture is highly complex and challenging. End-to-end anastomosis can be adopted for short-segment strictures, while ileal ureter or autologous kidney transplantation is commonly applied for long-segment urethral strictures. Nevertheless, various complications occur, including underlying intestinal obstruction, metabolic acidosis,

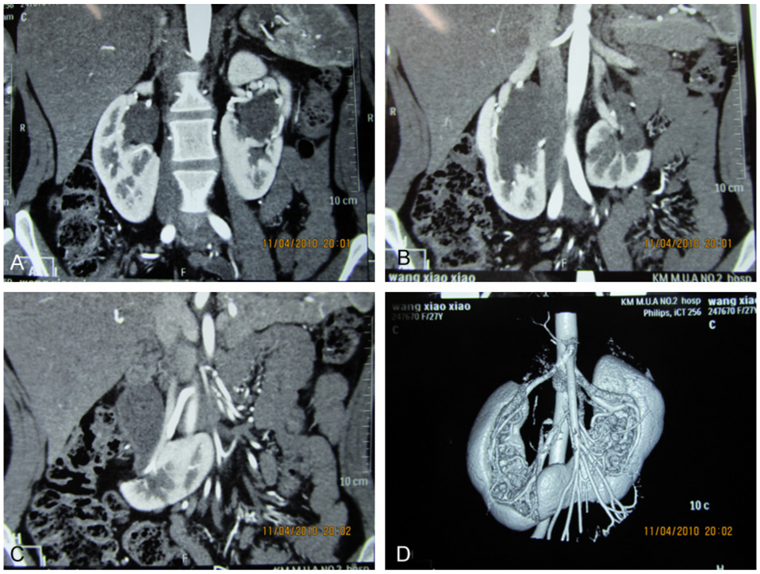

Figure 3. The postoperative CTU was performed on a 27-year-old patient one year after ureterocalicostomy. A-C: plain CT scan to the ureters; D: 3D CT scan to the ureters. CTU: CT urography.

electrolyte imbalance, secondary stone formation, and urinary tract infection, with large surgical trauma and slow postoperative recovery [19]. Hence, it is important to select postoperative patients with less trauma and complications for a better prognosis and postoperative quality of life.

Ureterocalicostomy was first invented by Neuwirt in 1947. Hawthorne et al. first proposed and improved the surgical methods [16, 20]. Laparoscopically-assisted technique was the first to be reported and robot-assisted ureterocalicostomy has emerged recently [21-23]. Ureterocalicostomy, as one traditional treatment for upper ureteral stricture, is also one feasible method especially for those with ureteropelvic junction stricture. Iatrogenic ureteral damage and stricture are common complications of pelvic surgery and radiation therapy. The upper segment of ureters is the most common susceptible site (91%) while mid-length and proximal 1/3 segment are rarely affected (7% and 2%, respectively) [2, 4]. A previous study showed that surgical incisions in the waist for ureterocalicostomy were suitable for upper ureteral strictures [5]. Guiter et al. reported that the success rate of tension-free and water-tight ureteral anastomosis in the treatment of ureteral stricture was >90% [24]. Furthermore, it revealed that the success rate of (robot-assisted) laparoscopic ureterocalicostomy was > 90% as laparoscopic techniques develop [25]. However, comparative studies of the two are still lacking.

Among patients with pyeloureteroplasty or treatment of renal and upper ureteral calculus, some of them developed secondary lesions like hydronephrosis or renal and ureteral infection, which leads to tight incarceration of stones in the peripheral urothelial mucosa, and ureterocalicostomy is one alternative for circumstances with difficulties in treating upper ureteral stricture through a conventional operation.

Surgical indications were as follows: 1) recurrent ureteropelvic junction obstruction; 2) upper ureteral stricture with or without lower calyx calculi; 3) recurrent renal calculi with upper ureteral stricture; 4) avulsion of upper part of ureter; 5) length of upper ureteral stricture greater than 4 cm. Furthermore, the surgery is not suitable for patients with heavy infection, high tension in anastomosis of ureter and lower calyx, or poor ipsilateral renal function on the injured side. Ureterocalicostomy involves preservation of the inferior pole of the kidney and anastomosis of ureter and lower calyx with amputation of partial inferior pole of kidney. We believe that preservation of the inferior pole of kidney is beneficial for the tissue and local blood supply in the perioperative period, which can enhance the success rate of operation. In our study, 12 of the 13 patients had ureterocalicostomy successfully. There are few reports on ureterocalicostomy in treating secondary long-segment upper ureteral stricture, because of the complexities of the procedure in the operation area, with uncertainties of intraoperative and postoperative complications. Hence, we decided to adopt ureterocalicostomy for reconstruction of the upper urinary tract to avoid permanent nephrostomy after overall preoperative evaluation and good communication with patients and their families. After surgery, a good functional outcome was

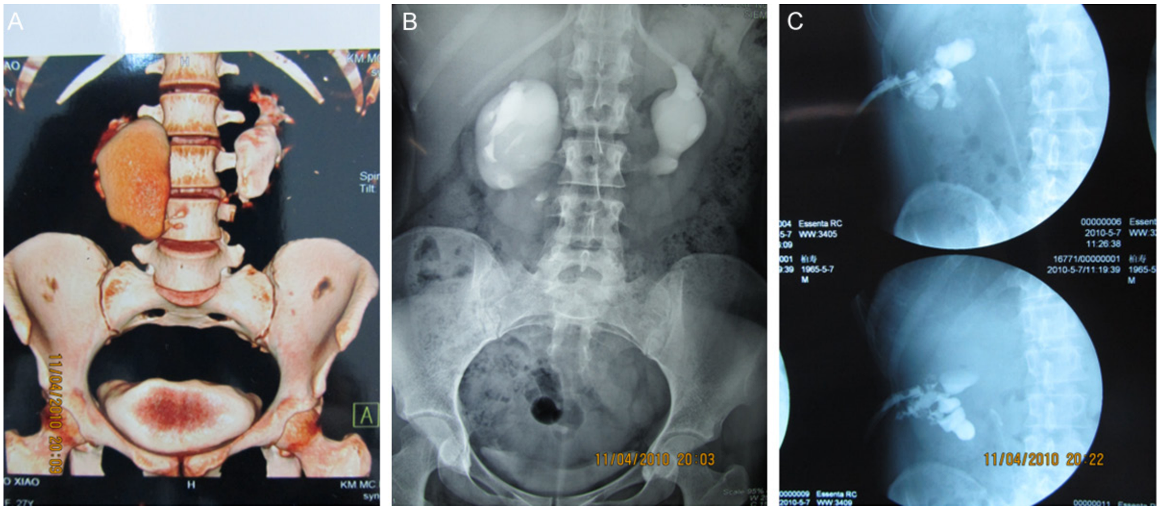

Figure 4. The postoperative KUB and IVU were performed on one 67-year-old male 8 months after ureterocalicostomy A and B: KUB of the ureters; C: IVU of the ureters. KUB: kidney ureter bladder; IVU: intravenous urography.

Table 3. Comparison of serum creatinine levels duringfollow-up

Item	Before surgery	Six months after surgery	t	P
Serum creatinine (μmol/L)	118.92±23.23	95.45±25.62	2.351	0.028
cystatin C (mg/L)	1.16±0.21	0.93±0.24	2.498	0.020
eGFR (CKD-EPI) (mL·min^{-1} (1.73 m^2)$^{-1}$)	90.23±6.23	96.23±5.92	2.418	0.024

Note: eGFR: estimated glomerular filtration rate; CKD-EPI: Chronic Kidney Disease Epidemiology Collaboration.

achieved in all patients. During the perioperative period, 3 patients developed fever and 2 patients had hematuria and irritation of lower urinary tract, of which resolved after symptomatic treatment. Moreover, postoperative KUB, IVU, and CTU revealed no ureteral stenosis. The results demonstrate that ureterocalicostomy is a feasible and reliable treatment for relieving secondary long-segment upper ureteral stricture.

Serum creatinine and cystatin C were utilized to evaluate postoperative renal function. Serum creatinine level plays an irreplaceable role in evaluating renal function, and diagnosis of acute kidney injury is made based on serum creatinine and urine volume [26, 27]. However, serum creatinine level is not improved until glomerular filtration rate is reduced to less than half due to the influence of diet, age, and other factors [28]. Therefore, we also adopted cystatin C level to evaluate renal function since cystatin C level was less affected by other factors and is relatively stable in the blood, and can be used to reflect changes in the glomerular filtration rate. Previous studies have unveiled that cystatin C level is positively correlated to the degree of renal impairment [29]. Generally, ureteral strictures cause ureteral obstruction and hydronephrosis, which further leads to decreased renal function. Our study showed much enhanced postoperative renal function without ureteral obstruction and hydronephrosis compared with that before surgery.

All patients received the surgical treatments successfully and safely. To achieve the goal, the following points are to be noted. First, the kidney, hilum, and upper ureter need to be well separated during the operation and the renal sinus should be incised in some cases with the intrarenal pelvis. Injury to the great vessels should be avoided, so as to manage the renal artery and facilitate effective hemostasis during the procedure. The peritoneum needs to be incised at first to identify the adhesion of kidney and abdominal organs. Scissors are employed for sharp dissection if there is firm adhesion. If there are still some difficulties for dissection, the peritoneum should be incised at the junction of peritoneum and the kidney adhered along the renal surface to avoid damage to renal capsule. Secondly, the inferior pole of the kidney should be well isolated and incised with hemostasis. The lower calyx needs to be well exposed. Tension of uretero-calyceal anastomosis is required to be low enough, and the ureter and calyx need to be stitched using 5-0 absorbable sutures. Thirdly, it is suggested that the indwelling double J stent with version F6 or higher should be adopted and renal blood flow restored as soon as possible during the procedure. Drainage tube should be placed around the anastomosis. Double J stent should be indwelling for 2-3 months.

The limitations of this research are as follows: This is a single-center study with small sample, thus multicenter studies will be needed with increased sample size to get a more precise conclusion in the future. We have not yet been able to identify the advantages and disadvantages of postoperative recovery between open surgery and laparoscopic surgery, which should also be analyzed. In addition, our goal for the future is to observe an improvement of postoperative stricture and complications and whether there is restricture during long-term follow-up, and further ameliorate the indexes of early renal function such as β2 microglobulin in blood and urine, and urine microalbumin used to observe the postoperative renal injury for further prospective study.

In sum, ureterocalicostomy is a safe and valid treatment for secondary ureteropelvic junction obstruction or long-segment upper ureteral stricture with satisfactory outcomes.

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Disclosure of conflict of interest

None.

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