International Urology and Nephrology (2019) 51:1955–1960
https://doi.org/10.1007/s11255-019-02252-9

UROLOGY - ORIGINAL PAPER

Analysis of the clinical effect and long-term follow-up results of retroperitoneal laparoscopic ureterolithotomy in the treatment of complicated upper ureteral calculi (report of 206 cases followed for 10 years)

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Received: 14 June 2019 / Accepted: 30 July 2019 / Published online: 10 August 2019

Abstract

Purpose To summarize the experience of retroperitoneal laparoscopic ureterolithotomy (RLU) in the treatment of upper ureteral calculi and long-term follow-up results and compare them with ureteroscopic lithotomy (URL) and percutaneous nephrolithotomy (PCNL).

Methods The clinical data of 585 patients with complex upper ureteral calculi who met the inclusion criteria from January 2006 to December 2017 were retrospectively analyzed. There were 206 cases treated with RLU, 201 cases treated with URL and 178 cases treated with PCNL. The operation time, hospitalization time, stone clearance rate, incidence of postoperative complications and recurrence rate were observed and compared among the three groups.

Results Among 585 eligible patients, 206 cases were treated with RLU, 201 cases were treated with URL and 178 cases were treated with PCNL. The stone clearance rate (98.54%), postoperative complication types and rate (0.97%) in the RLU group were superior to those in the URL group and the PCNL group ($P < 0.05$). There was no significant difference in the recurrence rate (3.88%) between the RLU group and the other two groups ($P > 0.05$).

Conclusion Retroperitoneal laparoscopic ureterolithotomy has many advantages in the treatment of upper ureteral calculi, including high stone clearance rate, less complications especially in ureteral stricture. Retroperitoneal laparoscopic ureterolithotomy is also safe to treat upper ureteral calculi accompanied with severe urinary tract infection.

Keywords Retroperitoneal laparoscopic ureterolithotomy · Ureteroscopic lithotripsy · Percutaneous nephrolithotomy · Upper ureteral calculi · Curative effects

Abbreviations

RLU	Retroperitoneal laparoscopic ureterolithotomy
URL	Ureteroscopic lithotomy
PCNL	Percutaneous nephrolithotomy
ESWL	Extracorporeal shock wave lithotripsy
UAS	Ultrasonically activated scalpel
IVU	Intravenous urography

Introduction

Ureteral calculi are common diseases with more than 12% morbidity rate [1]. Calculi can cause urinary tract obstruction, which in turn leads to severe pain, hydronephrosis, urinary tract infections and different renal dysfunction [2, 3]. The principle of treatment is to remove upper urinary tract obstruction, alleviate upper urinary tract dilatation and urine accumulation, control the progress of infection, and then carry out treatment to eliminate calculi [4].

Majority of ureteral calculi can be treated with extracorporeal shock wave lithotripsy (ESWL), ureteroscopic

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lithotripsy (URL), and percutaneous nephrolithotomy (PCNL), which can prevent most patients from open surgery [5]. Retroperitoneal laparoscopic ureterolithotomy (RLU) can be used for ureteral calculi with large size, hard texture, long impact history, obvious fibrous or granulation hyperplasia and complete obstruction of isolated kidney [6–8].

To better compare the clinical efficacy of RLU, URL, PCNL in the treatment of complicated upper ureteral calculi, we retrospectively analyzed the clinical data of 585 patients with complicated upper ureteral calculi treated in our hospital, and followed up these patients for a long time.

Patients and methods

Clinical materials

From January 2006 to December 2017, a total of 1354 patients with upper ureteral calculi were treated in our hospital, of which 585 patients with complicated upper ureteral calculi met the inclusion criteria. The inclusion criteria were as follows: (1) the residence time of stones in ureter was more than 8 weeks, intravenous urography (IVU) showed the maximum diameter was more than 0.8 cm; (2) ipsilateral pyelic separation was larger than 3.0 cm; (3) ureteral distortion or stricture at or below the stone site; (4) ureteral polyps were formed at the stone site or below the stone. Those who met the above two criteria were diagnosed as complex upper ureteral calculi [9–11]. Exclusion criteria: (1) previous history of ipsilateral renal or ureteral surgery; (2) ipsilateral renal calculi; (3) bilateral ureteral calculi. The study protocol was approved by the Biomedical Ethics Committee of the Tenth Hospital in Shanghai, and written informed consent was obtained from all patients or their relatives.

Surgical techniques

We usually perform RLU surgery as follows: under general anesthesia, patients were placed in the healthy lateral position. A 2.0 cm incision (point A) was cut longitudinally in posterior axillary line and under costal margin, and then muscle layer and lumbodorsal fascia was bluntly separated. The peritoneum was separated by the push with index finger, and then retroperitoneal space was created with a self-made balloon inflated with 500 ml air for 2 min. Under the guide of index finger, a 10 mm and 5 mm trocar was, respectively, inserted at one finger above iliac crest in midaxillary line (point B) and under costal margin in anterior axillary line (point C). Another 10 mm trocar was placed at point A. The monitor was inserted through point B. CO2 pressure was maintained between 10 and 15 cm H_20 (1 cm $H_20 = 0.098$ kPa). Ureter was found from the anterior medial side of psoas major muscle. The ureter segment at calculi was separated. The proximal ureter segment near calculi was clamped with a grasping forceps to prevent calculi moving into renal pelvis. Ureter was cut open with a self-made endoscopic knife and then the calculi were taken out. If the calculi moved into renal pelvis, renal pelvis must be separated along ureter. A semi-soft guide wire was inserted into a double J stent, and then the double J stent was inserted downwards into the ureter through the ureter incision. When the entire double J stent nearly was inserted into the ureter, the proximal end of double J stent was clamped with a grasping forceps, and the guide wire was removed, and then the proximal end of double J stent was inserted into the upper ureter and moved to renal pelvis. This insertion method was like the snake-catching technique in folk, so we called it as "snake-catching method (Fig. 1)". Ureter incision was discontinuously sutured with a 4-0 absorbable suture. A drainage tube was indwelled in the retroperitoneal cavity.

URL and PCNL have been described previously [12–14].

Summarizing the experience of RLU, we conclude that the indications for RLU surgery are similar to open surgery: (1) ureteral calculi failed by ESWL, URL and PCNL treatment; (2) other lesions of the ureter or adjacent tissue need to be treated simultaneously; (3) long diameter of stones is greater than 1.5 cm, obstruction time is longer, ureteral conditions are poor and other treatment methods are difficult to implement. We have the following experience in RLU: (1) each patient should receive ultrasonography, KUB and CT (CTU is a better choice) to determine the location and adjacent relationship of calculi; (2) psoas major muscle, inferior pole of kidneys and iliac vessels are the anatomical markers to accurately find ureters; (3) after the position of ureter

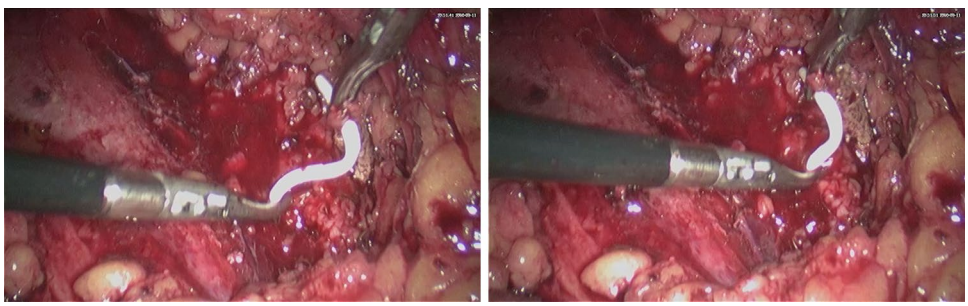

Fig. 1 Double J tube placement method—"Snake-catching method"

calculi was determined, the proximal ureter segment near calculi was clamped with a grasping forceps to prevent calculi moving into renal pelvis; (4) if it is difficult to find ureter due to obesity, inflammatory adhesions and so on, we can find ureter from inferior pole of kidneys and then separate downwards to find calculi; (5) we must cut ureter with scissors or knife because ultrasonically activated scalpel (UAS) can hurt ureteral mucosa and then result in postoperative ureteral stricture, and we have a unique experience in ureteral incision sutures and double J stents. Details as follows: (1) discontinuous suture can ensure the unobstructed space of ureteral lumen; (2) suture with seromuscular layer and satisfactory alignment of surgical edge can avoid ureteral stricture resulting from hypertrophic scar; (3) we must pay attention to the suture interval, the excessively tight suture may result in poor blood supply and stenosis, while sparse suture may result in leakage of urine; (4) we recommend "snake-catching method" to indwell the double J stent, and this convenient and practical method has the advantages of simple operation and short learning curve.

Study variables

All patients were followed up until December 2018. We counted the basic information of the patient, such as age, gender, stone side, and stone size. The operation time and hospitalization time of the three groups were recorded. The stone clearance rate and postoperative complications during hospitalization were observed in the three groups. Stone clearance was defined as residual stones with abdominal plain film reexamined < 3 mm in diameter 3 days after operation, infection was defined as more than 7 days of antibiotic treatment after operation, and hemorrhage was defined as postoperative hemoglobin (HB) concentration < 70 g/L, which required blood transfusion. All patients were followed up 1 month after operation, urinary CT was performed to determine whether there were residual stones, hydronephrosis recovery and D-J tube position. B-ultrasound examination [computed tomography urography (CTU), if necessary] was followed up every 6 months to evaluate the recurrence of stones and hydronephrosis to observe and analyze the clinical efficacy.

Statistical method

Statistical Package for the Social Sciences software (SPSS, version 20.0) was used to analyze and process the data in this paper. The measurement data ($\bar{x} \pm s$) were analyzed. The data were compared by nonparametric test, the counting data were expressed as percentage, and the data were compared by χ^2 test. $P < 0.05$ indicated statistical significance.

Results

General information

A total of 585 eligible complicated upper ureteral calculi patients were included in our study cohort from 2006 to 2017. Among them, 206 cases were treated with RLU, 201 cases were treated with URL and 178 cases were treated with PCNL. Table 1 shows the characteristics and the χ^2 test for comparison of the eligible patients with different treatments. There was no significant difference in gender, age, stone location and stone size ($P > 0.05$), but there were significant differences in operation time and hospitalization days among the three groups ($P < 0.05$). In addition, we can conclude that the operation time (69.53 ± 17.93 min) and hospitalization time (13.20 ± 5.86 days) of PCNL group were longer than that of the other two groups.

Table 1 Characteristics for our included patients

Characteristics	RLU	URL	PCNL	*P* value
Total	206	178	201	
Age (years)	56.24 ± 12.32	56.43 ± 12.36	56.20 ± 11.90	0.957
Gender				0.473
Male	144 (69.9)	138 (68.7)	132 (74.2)	
Female	62 (30.1)	63 (31.3)	46 (25.8)	
Stone side				0.555
Right	122 (59.2)	98 (55.1)	109 (54.2)	
Left	84 (40.8)	80 (44.9)	92 (45.8)	
Stone size (mm)	1.88 ± 0.68	1.79 ± 0.53	1.85 ± 0.74	0.752
Operation time (min)	50.36 ± 18.72	46.42 ± 12.25	69.53 ± 17.93	**< 0.001**
Hospitalization time (days)	8.23 ± 2.44	7.12 ± 3.69	13.20 ± 5.86	**< 0.001**

RLU Retroperitoneal laparoscopic ureterolithotomy, *URL* Ureteroscopic lithotomy, *PCNL* Percutaneous nephrolithotomy

Bold values indicate the results are statistically significant

Clinical effect of RLU and URL

For 206 patients with RLU, the stone clearance rate was 203 (98.54%), the recurrence rate was 8 (3.88%), and the incidence of postoperative complications was 2 (0.97%). For 178 patients with URL, the stone clearance rate was 155 (87.08%), the recurrence rate was 9 (5.06%), and the incidence of postoperative complications was 13 (7.30%). For postoperative complications, only two cases of ureteral stricture occurred in RLU group. But for URL group, there were three cases of infection, one case of bleeding and nine cases of ureteral stricture. The stone clearance rate in RLU group was higher than that in URL group, and the stone recurrence rate and postoperative complication rate in URL group were significantly lower than those in URL group. There was no significant difference in stone recurrence rate between the two groups ($P > 0.05$), but there was significant difference in stone clearance rate and postoperative complications ($P < 0.05$) (Table 2).

Clinical effect of RLU and PCNL

For 201 patients with PCNL, the stone clearance rate was 186 (92.54%), the recurrence rate was 7 (3.48%), and the incidence of postoperative complications was 17 (8.46%). In terms of postoperative complications, there were four cases of infection, six cases of bleeding, one case of shock/death, one case of D-J tube drop and five cases of ureteral stricture in PCNL group. There was no significant difference in recurrence rate between the two groups ($P > 0.05$), but there was significant difference between the two groups in stone clearance rate and postoperative complications ($P < 0.05$) (Table 3).

Table 2 Patients outcomes after operation (RLU and URL)

Characteristics	RLU	URL	*P* value
Total	206	178	
Stone clearance rate	203 (98.54)	155 (87.08)	**< 0.001**
Recurrence rate	8 (3.88)	9 (5.06)	0.577
Postoperative complication	2 (0.97)	13 (7.30)	**< 0.001**
Infection	0 (0.00)	3 (1.68)	0.061
Bleeding	0 (0.00)	1 (0.56)	0.281
Shock/death	0 (0.00)	0 (0.00)	–
D-J tube drop	0 (0.00)	0 (0.00)	–
Ureteral stricture	2 (0.97)	9 (5.06)	**0.017**

RLU Retroperitoneal laparoscopic ureterolithotomy, *URL* Ureteroscopic lithotomy

Bold values indicate the results are statistically significant

Table 3 Patients outcomes after operation (RLU and PCNL)

Characteristics	RLU	PCNL	*P* value
Total	206	201	
Stone clearance rate	203 (98.54)	186 (92.54)	**0.003**
Recurrence rate	8 (3.88)	7 (3.48)	0.830
Postoperative complication	2 (0.97)	17 (8.46)	**< 0.001**
Infection	0 (0.00)	4 (1.99)	**0.042**
Bleeding	0 (0.00)	6 (2.99)	**0.012**
Shock/death	0 (0.00)	1 (0.50)	0.311
D-J tube drop	0 (0.00)	1 (0.50)	0.311
Ureteral stricture	2 (0.97)	5 (2.49)	0.239

RLU Retroperitoneal laparoscopic ureterolithotomy, *PCNL* Percutaneous nephrolithotomy

Bold values indicate the results are statistically significant

Discussion

With the development of minimally invasive techniques, there are more and more treatment methods for ureteral calculi, including extracorporeal shock wave lithotripsy (ESWL), ureteroscopic lithotripsy (URL), percutaneous nephrolithotomy (PCNL) and retroperitoneal laparoscopic ureterolithotomy (RLU) [15]. Although it has been widely accepted that ESWL is the preferred treatment for ureteral calculi, ESWL has lower success treatment rate for complex ureteral calculi including larger size, harder texture, longer impact time, encapsulated with granulation tissue or polyp, or accompanied with ureter stenosis [16]. Ureteroscopic lithotripsy has satisfactory curative effects for lower ureter calculi, but URL can not satisfactorily treat majority of upper ureter calculi due to movement into renal pelvis and ureteral tortuosity or stenosis [17]. Percutaneous nephrolithotomy has high success rate to treat ureter calculi above the fourth lumbar vertebrae and ipsilateral kidney calculi, but PCNL has some severe complications including hemorrhage and infection [18, 19]. The above-mentioned treatment methods have each limits, and the open surgery is massively invasive. Laparoscopic technique may be an alternative treatment for upper ureter calculi. Retroperitoneal laparoscopic ureterolithotomy has many advantages including higher stone-free rate, no contraindication with acute infection, simultaneous treatment on retroperitoneal disease, less severe infective complications resulting from high pressure of perfusion [20–22]. However, the long-term follow-up results of RLU in the treatment of upper ureter calculi are insufficient.

Urinary tract infection is one of the common complications of ureteroscopic lithotripsy, and severe urinary sepsis has a high mortality rate. Jean [23] reported that the incidence of post-URL urinary infection was 1% and the incidence of post-URL urinary sepsis was 0.3%. This study found that none of the 206 cases had postoperative infection;

the incidence of infection was 1.68% after URL and 1.99% after PCNL. At present, domestic and international guidelines recommend preoperative preventive application with antibiotics to reduce the incidence of post-URL urinary infection. The reasons of post-URL urinary infection are renal pelvic hypertension and reverse absorption of bacterial endotoxin due to continuous perfusion. Therefore, URL and PCNL must be operated without infection. Since RLU rapidly reduces the pressure of renal pelvis, RLU can safely and effectively cure infectious calculi with stable hemodynamics.

There are reports in the literature that the incidence of post-URL ureteral stricture was 3~24% [24, 25]. The incidence of ureteral stricture in our study was only 0.97%, which was lower than the incidence of post-URL ureteral stricture in past democratic and foreign literatures. The heat energy of the holmium laser can damage ureteral mucosa near calculi, and then the poor blood supply of ureteral mucosa result in scar healing, which may be an important cause of postoperative ureteral stenosis. Postoperative ureteral stenosis will further aggravate obstructive nephropathy and impair renal function, which is the main cause of calculi-related renal dysfunction. Johnson [26] found that the incidence of nephrectomy related with surgical treatment of upper urinary calculi was 9.6%. In our study, only two cases of hydronephrosis resulted from postoperative ureteral stricture were found, and no patient received nephrectomy. The principle of nephrectomy we observe is: intraoperative adhesion is severe, exfoliation will cause severe damage to the renal hilum, or uncontrolled bleeding during surgery; kidney stones with renal malignant tumors, impaired renal sinus deformity; kidney stones with severe infections or pyonephrosis; complex renal calculus with pyelonephritis renal parenchymal atrophy without function [27]. This suggests that RLU has a lower incidence of ureteral stricture and better renal function protection on the treatment of upper ureteral calculi.

At present, PCNL is a well developed and widely used technology. However, PCNL has many severe complications including visceral injury (such as liver, spleen, pleura, duodenum, and colon), great vascular injury (such as renal vein and vena cava), nephrectomy resulted from renal massive hemorrhage and death resulted from severe infections [18]. Skolarikos [28] reported that the blood transfusion rate, sepsis incidence, pleural injury incidence and colon injury incidence of standard passage PCNL is 11–12.3%, 0.9–4.7%, 2.3–3.1%, and 0.2–0.8%, respectively. This study found that the incidence of bleeding after PCNL was 2.99%. Since RLU is operated under direct vision, non-puncture operation has extremely low possibility of internal organ injury and large blood vessel injury [29].

The stone-free rate (SFR) of URL in the treatment of ureteral calculi was 72–85.6% [30, 31], while the SFR of PCNL was 86% [29]. In this study, the SFR of RLU in the treatment of upper ureteral calculi was 98.57%, which was higher than URL (87.08%) and PCNL (92.54%). Since there is no continuous irrigation and contact operation between laser fiber and calculi, and calculi was removed integrally, RLU has a very low probability of residual calculus resulted from transposing.

In addition to the advantages discussed above, we also found that RLU has some drawbacks. Due to the anatomical position, the abdominal aorta is easily damaged during surgery. Long postoperative recovery time, long hospitalization time, and high cost are also obvious shortcomings. At the same time, RLU has high requirements for surgeons and the learning curve is too long to ignore.

Conclusion

Compared with URL and PCNL, RLU can have many advantages such as simultaneous treatment on retroperitoneal diseases, higher SFR, less perioperative complications, shorter hospital stay, lower incidence of ureteral stricture and less nephrectomy. Retroperitoneal laparoscopic ureterolithotomy can safely remove upper ureter calculi accompanied with urinary tract infections. Retroperitoneal laparoscopic ureterolithotomy can completely replace ureterolithotomy to remove large-size upper ureteral calculi with long impact time, obvious polypoid hyperplasia and urinary tract infection.

Acknowledgements The authors are grateful for the invaluable support and useful discussions with other members of the Urological department.

Author contributions KW, GW and BP designed the research. HZ and JH acquired the data. KW, LY, HS and JG analyzed the results. KW and GW wrote the article. BP revised and provided critical comments. All authors read and approved the final manuscript.

Funding This work was supported by the National Natural Science Foundation of China (Grant No. 81870517).

Compliance with ethical standards

Conflict of interest The authors of this manuscript have no conflict of interest.

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