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ORIGINAL PAPER

Retrograde intrarenal surgery in the management of symptomatic calyceal diverticular stones: a single center experience

Xiong Chen[1,2] · Dongjie Li[1] · Yuanqing Dai[2] · Yao Bai[2] · Qizhan Luo[2] · Zhongwei Zhao[1] · Hequn Chen[3] · Xiaobo Zhang[1,2]

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Abstract To evaluate the outcome of RIRS in managing symptomatic calyceal diverticular as a minimally invasive option, we retrospectively reviewed the records of 43 patients who underwent RIRS from 2005 to 2014 for symptomatic calyceal diverticular stones. A month after the initial operation, the success rate was (81.4 %, 35 patients) of which 21 (48.83 %) patients were stone free and 14 (32.6 %) patients had clinically insignificant residual fragments (CIRFs), and 90 % patients were symptom free. Eight patients (16.6 %) had significant residual fragments (>3 mm), five of them became completely stone free after the second procedure, other three patients were symptom free and underwent a routine follow-up. The final treatment success rate was 93.0 %. The initial success rate in the lower calyx was significantly lower than the other calices ($P = 0.040$). In addition, the association between the stone size and the initial treatment success was significant ($P = 0.036$). There was no association between any of our other variables and the success rate. The mean first operative time was 60.95 ± 12.43 min (range 34–92). No major complication (Clavien III–V) occurred, although there were five minor complications (11.6 %) (Clavien I–II). There were no admissions to intensive care or deaths in our series, the mean hospitalization time was 1.77 ± 0.80 days. The management of calyceal diverticular calculus with RIRS is highly effective and can be accomplished with low morbidity.

Keywords Retrograde intrarenal surgery (RIRS) · Calyceal diverticular stones · Stone-free rate

✉ Xiaobo Zhang
xiaobozxb@hotmail.com

1 International Medical Center, Xiang Ya Hospital, Central South University, Changsha 410008, Hunan, People's Republic of China

2 Department of Geriatric Medicine, Xiang Ya Hospital, Central South University, Changsha 410008, Hunan, People's Republic of China

3 Department of Urology, Xiang Ya Hospital, Central South University, Changsha 410008, Hunan, People's Republic of China

Introduction

Calyceal diverticula was first described by Rayer in 1841, which is believed to originate during the fifth or sixth gestational week, when developmental anomalies of the renal vessels interfere with the degeneration of the fourth-order collecting ducts [1]. By definition, these peripherally located cavities are lined with transitional stratified epithelium and have no secretory function. They usually communicate with a calyceal group by a neck of variable width. Urine usually enters the cavity by retrograde passive filling. It is reported that calyceal diverticula occur in no more than 0.6 % of the population, but the incidence of stones within calyceal diverticula is 10–50 % [2, 3]. Stones in the calyceal diverticula are a rare pathologic finding in patients with urinary stone diseases.

Indications for treatment include pain, recurrent infection, increased stone growth, hematuria or a large size that compresses or progressively damages contiguous renal parenchyma. As in all other stone-forming conditions, one has to consider all treatment forms: extracorporeal shock-wave lithotripsy (ESWL), endoscopic or pecutaneous procedures, laparoscopy, or open surgery, and the aim is to remove the stone and to enlarge the diverticular neck to avoid recurrence. Since Fuchs reported their first ureterorenoscopic management of stone disease in 1990, the treatment does not stop with evolution of the new techniques in the endourologic field [4].

Due to the rare incidence of this disease, there are a small number of published studies that show the outcomes in patients who have been treated with RIRS. We describe our experience with RIRS in 43 patients with symptomatic calyceal diverticular stone.

Patients and methods

Patients

Between January 2005 and January 2014, 43 patients (28 men and 15 women) were treated for symptomatic calyceal diverticular stone disease with RIRS, by the same team at our institution. Patient selection for this intervention included previously failed SWL and the preference of patients and surgeons. All patients were preoperatively evaluated with urine culture, serum biochemistry, urinary ultrasonography, plain radiography, noncontrast computed tomography (CT) or intravenous urography (IVU), or both. The stone size was determined by measuring the maximum diameter of the stone on noncontrast CT. In patients with multiple renal stones, the stone size was calculated as the sum of the greatest dimensions of each stones.

Surgical technique

Before the procedure, intravenous antibiotics were administrated. Under general anesthesia, the patient was positioned in the lithotomy position. After draping, one hydrophilic guidewire was placed in the renal pelvis through semirigid ureteroscopy. A ureteral access sheath (UAS) was placed over the hydrophilic guidewire, and the f-URS was passed through the UAS. When necessary, the ureteral orifice was dilated. If the UAS failed, the f-URS was advanced into the renal pelvis over the guidewire. Different types of flexible ureteroscopes were used, including Flex-X (Karl Storz, Germany), URF-P5 or URF-V (Olympus, Japan).

A manual irrigation pump was used to improve visualization. The diverticular neck was identified by f-URS, contrast was injected, and the fluoroscope was used to identify the diverticulum in case of difficulties.

A 200 μm holmium laser fiber was used to incise the diverticular neck and to fragment any diverticular stone (Fig. 1). Incision of the diverticular neck by holmium laser was carried out gradually and carefully with high frequency and low energy (0.8 J, 20 Hz). The stones were fragmented in all cases, with the holmium laser at an energy level of 0.6–1.0 J and frequency of 10–20 Hz. Some fragments were removed using a nitinol basket for stone analysis, and the remaining fragments, which were considered smaller than 3 mm, were left for the patient to pass spontaneously. At the end of the procedure, we left a double-J stent in all of the patients to promote stone fragment clearance and to prevent obstruction by blood clots from laser incision and fragmentation.

The follow-up evaluation was performed 1 month after the initial operation, serum biochemistry, urinalysis, plain radiography, and abdominal ultrasonography were performed. CT was performed in some cases. The procedure was considered as successful in patients with complete stone disappearance (stone free) or insignificant residual fragment ≤3 mm on plain radiography. If the procedure was considered as successful, the pigtail stent was removed. In patients with residual calculi and symptoms, second-stage RIRS was performed. The same follow-up evaluation was performed 1 month after the second procedure. Assessment also was based on the presence or absence of symptoms and complications.

Statistical analysis was performed with the Mann–Whitney, Chi-square and Fisher' exact test using the Statistical Package for Social Sciences, version 17.0 (SPSS, Chicago, IL). Significance was assessed at $P < 0.05$.

Results

From January 2005 to January 2014, 43 patients (28 men and 15 women) with a mean age of 47.1 ± 14.0 years (range 15–70) underwent RIRS. The patient and stone characteristics are listed in Table 1. The mean first operative time was 60.95 ± 12.43 min (range 34–92). No major complication (Clavien III–V) occurred, although there were five minor complications (11.6 %) (Clavien I–II), which included two patients suffering from severe renal colic and three patients experienced postoperative fever. There were no admissions to intensive care or deaths in our series; the mean hospitalization time was 1.77 ± 0.80 days. 1 month after the initial operation, the success rate was (81.4 %, 35 patients) of which 21 (48.83 %) patients were stone free and 14 (32.6 %) patients had clinically insignificant residual fragments (CIRFs). Eight patients (16.6 %) had significant residual fragments (>3 mm), five of them became completely stone free after the second procedure, three patients were symptom free and underwent a routine follow-up. The final treatment success rate was 93.0 % (Table 2). All patients received routine follow-up every year with ultrasonography and plain radiography; there was no stone recurrence. We found that the initial success rate in the lower calyx was significantly lower than the other calices ($P = 0.040$). In addition, the association between the stone size and the initial treatment success was significant ($P = 0.036$). There was no association between any of our other variables and the success rate (Table 3).

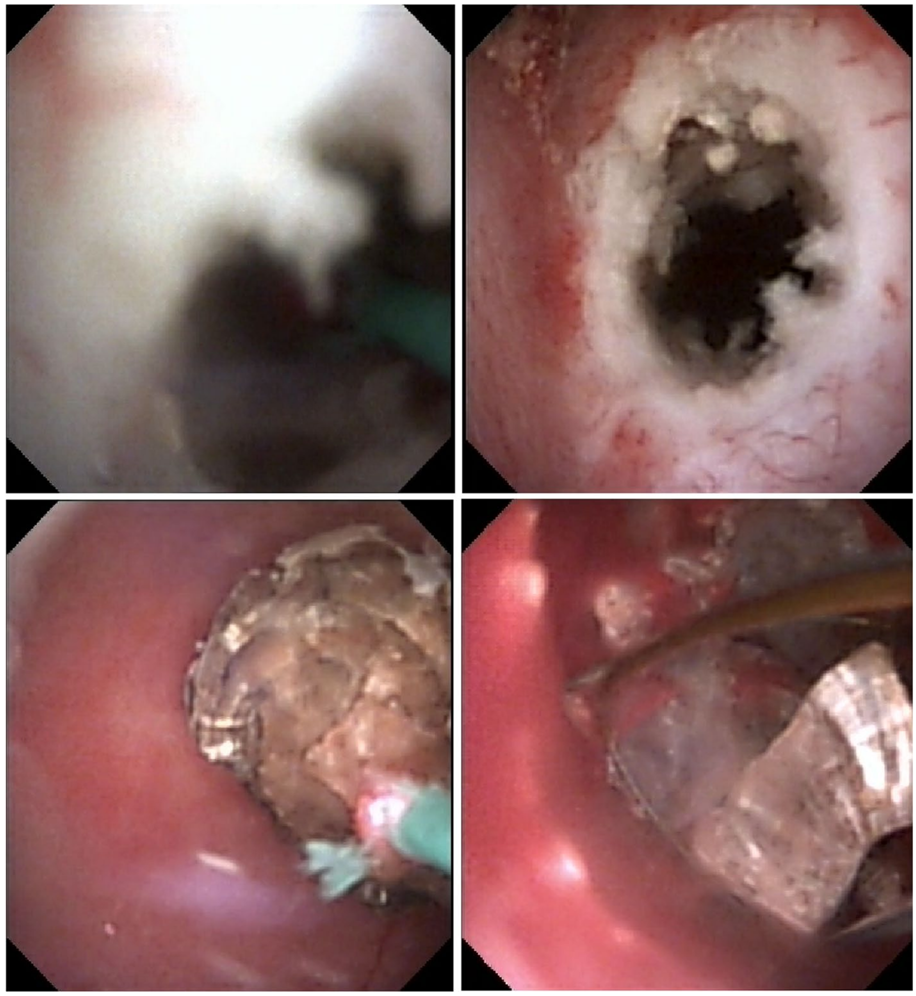

Fig. 1 Incision of the diverticular neck, the stones were fragmented, fragments were removed using a nitinol basket

Discussion

Calyceal diverticula are often detected incidentally on IVU or CT and it is reported that the incidence of calculi within calyceal diverticula is 10–50 % [5]. As symptomatic calyceal diverticula with stones is a rare disease there is no consensus on treatment. With improving experience and advancements in technology, various available minimally invasive modalities offer the highest symptomatic relief and stone-free rates [6–8]. Open surgical treatment has been largely replaced by a number of less invasive surgical and nonsurgical modalities. Although the stone-free rate with ESWL is low, ranging from 4 to 20 %, and enlargement of the diverticular neck cannot be achieved, ESWL is usually the first choice of management for calyceal diverticula with stones [6, 9, 10]. Streem and Yost [11] suggested that by limiting ESWL treatment to patients with relatively small calculi (1.5 cm) and a patent diverticular neck, stone-free rates could be relatively high. In cases of ESWL treatment failure, repeating the session of ESWL does not bring success and, therefore, other methods have to be proposed. Researches of PCNL treatment for stone-bearing calyceal diverticula suggest that stone-free rates are 70–100 %, with recurrence rates of 0–30 % [6, 12–17]. Despite PCNL having the higher stone-free rate (>90 %), percutaneous management of the calyceal diverticular stones is challenging because the space is usually narrow and identifying the diverticular neck is often difficult. In addition, it has a higher rate of complications compared with other modalities [18]. When the diverticulum is located anteriorly, which needs a tract that goes through more renal parenchyma and, hence, there is an increased risk of significant hemorrhage. An inaccessible calyceal neck may preclude endoscopic treatment. In such cases, laparoscopic treatment may be a promising approach, which was first successfully done in 1994 by Ruckle and Segura [19], despite no large series being reported; recently, Torricelli and Batista reported a case of robotic-assisted laparoscopic management of a calyceal diverticular calculus [20]. Fuchs et al. first described a retrograde endoscopic technique to manage calyceal diverticular stones, reporting stone-free rates of 73 % and symptom relief in 86 % of the patients [4].

Table 1 Demographic data and stone characteristics ($n = 43$)

Variable	No.	%	Mean ± SD	Minimum–maximum
Age (years)			47.1 ± 14.0	15–70
Gender				
Female	15	34.9		
Male	28	63.1		
BMI (kg/m^2)			21.7 ± 2.83	16.5–27.6
Symptoms				
Renal colic	23	53.4		
UTI	10	23.3		
Renal colic and UTI	10	23.3		
Previous SWL	19	44.2		
Stone side				
Left	23	53.5		
Right	20	46.5		
Stone length (mm)			10.6 ± 4.3	5–19
Stone number				
Single	33	76.7		
Multiple	10	23.3		
Stone site				
Upper pole	29	67.4		
Middle pole	9	21.0		
Lower pole	5	11.6		

SD standard deviation, *BMI* body mass index, *UTI* urinary tract infection, *SWL* shock-wave lithotripsy

Table 2 Operative and postoperative outcomes

Variable	Value
Mean operation time (min)	60.95 ± 12.43
Minor complication rate	5 (11.6 %)
Mean hospitalization time (day)	1.77 ± 0.80
Initial treatment success rate	81.4 %
Final treatment success rate	93.0 %
Final symptom-free rate	100 %

Table 3 Association of different variables and initial treatment failure

Variable	Treatment success	Treatment failure	*P*	Test
Age (years)	48.4 ± 13.3	41.25 ± 16.6	0.229	Mann–Whitney
Gender				
Female	13 (86.7 %)	2 (13.3 %)	0.692	Fisher's exact
Male	22 (78.6 %)	6 (21.4 %)		
BMI (kg/m^2)	22.1 ± 2.8	20.33 ± 2.5	0.147	
Symptoms				
Renal colic	17 (73.9 %)	6 (26.1 %)	0.207	Chi-square
UTI	8 (80 %)	2 (20 %)		
Renal colic and UTI	10 (100 %)	0 (0 %)		
Previous SWL				
Yes	16 (76.2 %)	5 (23.8 %)	0.457	Fisher's exact
No	19 (86.4 %)	3 (13.6 %)		
Stone side				
Left	19 (82.6 %)	4 (17.4 %)	1.000	Fisher's exact
Right	16 (80 %)	4 (20.0 %)		
Stone length (mm)	9.9 ± 0.4	13.4 ± 0.39	0.036	Mann–Whitney
Stone number				
Single	29 (87.9 %)	4 (12.1 %)	0.070	Fisher's exact
Multiple	6 (60 %)	4 (40.0 %)		
Stone site				
Upper pole	25 (86.2 %)	4 (13.8 %)	0.040	Chi-square
Middle pole	8 (88.9 %)	1 (11.1 %)		
Lower pole	2 (40.0 %)	3 (60.0 %)		

Since that, ureterorenoscopic access has been used in the management of these diseases for three decades. Retrograde intrarenal surgery management of stones in calyceal diverticulum and its related problems has been shown to be more efficacious than ESWL monotherapy and avoids the potential complications and discomfort of percutaneous and laparoscopic procedures.

Our series would suggest that RIRS treatment of stones in calyceal diverticulum can be accomplished with little morbidity. No patients experienced severe complications, and there were no admissions to intensive care or deaths in our series; the mean hospitalization time was 1.77 days. These figures compare favorably with previously published series of PCNL treatments. Our data showed one-session treatment success rate was 81.4 %, which was similar with those reported by others and was lower than those treated by PCNL [8, 21]. But the final treatment success rate after second surgery was 93 %, which was similar with those treated by PCNL. The development of high-definition f-URS may have increased its therapeutic potential, allowing us to obtain the best outcome, because we found the traditional fiber flexible ureteroscope provided a very dim image, especially in those bleeding cases. As many other studies had shown, in our study the stone size was an independent variable that affected the stone-free rate, but which could be improved by second procedure. It was documented that the rate of lower pole calyceal diverticula was 10–43 % in different studies [6, 8, 22]. Some studies described difficulties in accessing the lower pole calyceal diverticula, and retrograde treatment of such diverticula is associated with a significantly lower success rate in some patients [21, 23]. Our study shows the same results; patients with calyceal diverticular stones located in low renal pole were difficult to treat with RIRS. Unlike previous studies, Majed and colleagues described that the success rate in the lower calyx was relatively low compared with the other calices but without significant value. And whatever the location of the calyceal diverticula, they believed RIRS should be proposed as first-line therapy for stone-bearing diverticula with moderate stone burden [8]. Recently, Desai and colleagues described a micro-PCNL technique with reduced bleeding, length of hospital stay and improved analgesia when compared with standard PCNL, in which renal access and stone fragmentation are performed in a single step using a 4.85-F "all-seeing" needle [24]. Then they reported that Microperc is a safe and effective alternative to RIRS for the management of small renal calculi (<1.5 cm) and has similar stone clearance and complication rates when compared to RIRS [25]. This could be an interesting technique in the treatment of stones in calyceal diverticula especially in the lower pole, although there is no literature on this yet.

Identification and incision of the neck of calyceal diverticulum was a key step in our procedure. There was an endoscopic classification for calyceal diverticula: large neck; narrow and short neck; narrow and long neck; closed neck [26]. We recommended RIRS for management of calyceal diverticula with the first and second type, retrograde ureteropyelography can be used to find the neck of diverticulum. It is too difficult to find and incise the closed neck of diverticulum. The lower pole diverticulum with a long neck makes f-URS access difficult. Using the holmium laser to incise the diverticular neck provides wide exposure of the stone and enhances elimination of the stone later. It was important to avoid bleeding which obscured vision during the incision of the neck of diverticulum. Although the green light laser may be safer than the holmium laser in theory, it was in short supply in our hospital. We performed incision at a low-energy setting to avoid hemorrhage with a 200 μm holmium laser fiber (0.8w/Hz, 20 Hz) and manual irrigation.

As we know, the present study is the largest series involved in stones with calyceal diverticula that have been treated by RIRS, but our study has obvious limitations: the definition of stone free is a fragment no more than 3 mm, not no stones. Due to the rare prevalence of this disease, the most important limitation is that our study is single central, retrospective and statistically limited, so a large number of multicenter randomized controlled trials of high quality are still required to explore the different outcomes between RIRS and other techniques.

Conclusion

We demonstrate the feasibility, safety and effectiveness of stones with calyceal diverticula treated by RIRS. This technique should be considered as a first-line treatment of this pathology.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Rayer P (1841) Traits des maladies des reins 3:507
2. Kottasz S, Hamvas A (1977) Calyceal diverticula: review of the literature, a hypothesis concerning its aetiology, and report of 17 cases. Acta chirurgica Academiae Scientiarum Hungaricae 18:289–293
3. Shalhav AL, Soble JJ, Nakada SY, Wolf JS Jr, McClennan BL, Clayman RV (1998) Long-term outcome of caliceal diverticula following percutaneous endosurgical management. J Urol 160:1635–1639
4. Fuchs AM, Fuchs GJ (1990) Retrograde intrarenal surgery for calculus disease: new minimally invasive treatment approach. Urologe A 29:313–320
5. Middleton AW Jr, Pfister RC (1974) Stone-containing pyelocaliceal diverticulum: embryogenic, anatomic, radiologic and clinical characteristics. J Urol 111:2–6
6. Jones JA, Lingeman JE, Steidle CP (1991) The roles of extracorporeal shock wave lithotripsy and percutaneous nephrostolithotomy in the management of pyelocaliceal diverticula. J Urol 146:724–727
7. Krambeck AE, Lingeman JE (2009) Percutaneous management of caliceal diverticuli. J Endourol 23:1723–1729
8. Sejiny M, Al-Qahtani S, Elhaous A, Molimard B, Traxer O (2010) Efficacy of flexible ureterorenoscopy with holmium laser in the management of stone-bearing caliceal diverticula. J Endourol 24:961–967
9. Psihramis KE, Dretler SP (1987) Extracorporeal shock wave lithotripsy of caliceal diverticula calculi. J Urol 138:707–711
10. Ritchie AW, Parr NJ, Moussa SA, Tolley DA (1990) Lithotripsy for calculi in caliceal diverticula? Br J Urol 66:6–8
11. Streem SB, Yost A (1992) Treatment of caliceal diverticular calculi with extracorporeal shock wave lithotripsy: patient selection and extended followup. J Urol 148:1043–1046
12. Monga M, Smith R, Ferral H, Thomas R (2000) Percutaneous ablation of caliceal diverticulum: long-term followup. J Urol 163:28–32
13. Matlaga BR, Kim SC, Watkins SL, Munch LC, Chan BW, Lingeman JE (2006) Pre-percutaneous nephrolithotomy opacification for caliceal diverticular calculi. J Endourol 20:175–178
14. Hulbert JC, Reddy PK, Hunter DW, Castaneda-Zuniga W, Amplatz K, Lange PH (1986) Percutaneous techniques for the management of caliceal diverticula containing calculi. J Urol 135:225–227
15. Shalhav AL, Soble JJ, Nakada SY, Wolf JS Jr, McClennan BL, Clayman RV (1998) Long-term outcome of caliceal diverticula following percutaneous endosurgical management. J Urol 160:1635–1639
16. Bellman GC, Silverstein JI, Blickensderfer S, Smith AD (1993) Technique and follow-up of percutaneous management of caliceal diverticula. Urology 42:21–25
17. Kim SC, Kuo RL, Tinmouth WW, Watkins S, Lingeman JE (2005) Percutaneous nephrolithotomy for caliceal diverticular calculi: a novel single stage approach. J Urol 173:1194–1198
18. Turna B, Raza A, Moussa S, Smith G, Tolley DA (2007) Management of calyceal diverticular stones with extracorporeal

shock wave lithotripsy and percutaneous nephrolithotomy: long-term outcome. BJU Int 100:151–156
19. Ruckle HC, Segura JW (1994) Laparoscopic treatment of a stone-filled, caliceal diverticulum: a definitive, minimally invasive therapeutic option. J Urol 151:122–124
20. Torricelli FC, Batista LT, Colombo JR Jr, Coelho RF (2014) Robotic-assisted laparoscopic management of a caliceal diverticular calculus. BMJ Case Rep pii:bcr2014205437
21. Bas O, Ozyuvali E, Aydogmus Y, Sener NC, Dede O, Ozgun S, Hizli F, Senocak C, Bozkurt OF, Basar H, Imamoglu A (2015) Management of calyceal diverticular calculi: a comparison of percutaneous nephrolithotomy and flexible ureterorenoscopy. Urolithiasis 43:155–161
22. Abeshouse BS, Abeshouse GA (1963) Calyceal diverticulum: a report of sixteen cases and review of the literature. Urol Int 15:329–357
23. Batter SJ, Dretler SP (1997) Ureterorenoscopic approach to the symptomatic caliceal diverticulum. J Urol 158:709–713
24. Desai MR, Sharma R, Mishra S, Sabnis RB, Stief C, Bader M (2011) Single-step percutaneous nephrolithotomy (microperc): the initial clinical report. J Urol 186:140–145
25. Sabnis RB, Ganesamoni R, Doshi A, Ganpule AP, Jagtap J, Desai MR (2013) Micropercutaneous nephrolithotomy (microperc) vs retrograde intrarenal surgery for the management of small renal calculi: a randomized controlled trial. BJU Int 112:355–361
26. Dretler SP (1993) A new useful endoscopic classification of calyceal diverticula. 88th Congress AUA Abstract 843