Issue 2

CUTTING EDGE
UROLOGY

Read Online/Watch Videos

http://collections.medengine.com/urology/cutting-edge-urology/

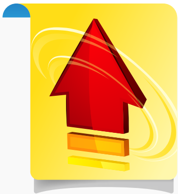
Springer Healthcare Education

In Patients with LUTS due to BPH,

℞ CONTIFLO ICON™

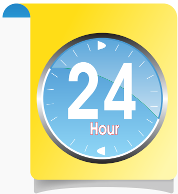
Tamsulosin Hydrochloride 0.4mg **Prolonged Release Tablets**

Tamsulosin with Innovative CONtrolled absorption technology



Delivers consistent drug levels over 24hrs[1,2]

- Better control of bothersome night-time symptoms of LUTS/ BPH, including nocturia
- Better QoS and QoL



Offers 24-hr symptom control[1,2]

- OD dose sufficient

Lower C-max & Drug intake independent of food consumption[1,2]

- Better cardiovascular safety profile
- Patient compliance

LUTS- Lower Urinary Tract Symptoms , BPH-Benign Prostate Hyperplasia, QoL- Quality of Life, QoS- Quality of Sleep, C-max- Maximum concentration of drug in the plasma

Ref: 1.Christopher R. Chapple And Emmanuel Chartier-Kastler. Pharmacokinetic profile of tamsulosin OCAS. Journal Compilation BJU International, 2006;98(2):9-12

2.Phillip K. Introduction and Summary. Journal Compilation BJU International, 2006;98 (2):1-2

Abbreviated Prescribing Information. CONTIFLOTM ICON.

GENERIC NAME: Tamsuosin Hydrochloride Prolonged Release Tablets. COMPOSITION:Each film-coated tablet contains: Tamsulosin HCl IP…0.4 mg (prolonged release.DOSAGE Form: Tablets for oral use. Description: CONTIFLO ICON contains tamsulosin hydrochloride, which is an antagonist of alphalA adrenoceptors in the prostate. Indications: For the treatment of sign and symptoms of benign prostatic hyperplasia (BPH). DOSE AND METHOD OF ADMINISTRATION: The recommended dose of CONTIFLO ICON (Tamsulosin HCl Prolonged Release Tablet) is 0.4mg once daily. It should be administered approximately one-half hour following the same meal each day. For those patients who fail to respond to the 0.4mg dose after 2 to 4 weeks of dosing, the dose of tamsulosin HCl prolonged release tablet can be increased to 0.8mg once daily. If discontinued or interrupted for several days at either the 0.4mg or 0.8mg dose, therapy should be started again with the 0.4mg once daily doseThe tablet should be swallowed whole and should not be crunched or chewed as this will interfere with the prolonged release of the active ingredient. Pregnancy: Pregnancy category B: Tamsulosin is not indicated for use in women. CONTRAINDICATIONS: Patients with known hypersensitivity to tamsulosin or any other component of this product. Reactions have included skin rash, urticaria, pruritus, angioedema and respiratory symptoms. WARNINGS AND PRECAUTIONS: Possibility of postural hypotension. Patients should be cautioned to avoid situations where injury could result should syncope occur. Tamsulosin should not be used in combination with other alpha adrenergic blocking agents. Caution is advised when alpha adrenergic blocking agents including tamsulosin are co-administered with PDE5 inhibitors. Alpha adrenergic blockers and PDE5 inhibitors are both vasodilators that can lower blood pressure. Concomitant use of these two drug classes can potentially cause symptomatic hypotension. Caution should be exercised with concomitant administration of warfarin and tamsulosin. Patients must be advised about the possibility & seriousness of Priapism. Intraoperative floppy iris syndromehas been observed during cataract surgery in some patients treated with alpha1 blockers, including tamsulosin. Advice patients considering cataract surgery to tell their ophthalmologist about use of contiflo Icon. DRUG INTERACTIONS: Tamsulosin 0.4mg should not be used in combination with strong inhibitors of CYP3A4 (e.g., ketoconazole). Tamsulosin should be used with caution in combination with moderate inhibitors of CYP3A4 (e.g., erythromycin), in combination with strong (e.g., paroxetine) or moderate (e.g., terbinafine) inhibitors of CYP2D6, in patients known to be CYP2D6 poor metabolizers particularly at a dose higher than 0.4mg (e.g., 0.8mg).. SHELF-LIFE: Please see Mfg. Date. Expiry date printed on pack. Do not use product after expiry date which is stated on packaging. Expiry date refers to last day of that month. STORAGE AND HANDLING INSTRUCTIONS: Store below 25□C, protected from light and moisture. Keep all medicines out of reach of children. For more information kindle write to : SUN HOUSE, 201 B/1,WESTERN EXPRESS HIGHWAY, GOREGAON EAST, MUMBAI-400063

Amphion

a SUN PHARMA division

CUTTING **EDGE**
Urology

Springer Healthcare Education

May 2019

Springer Healthcare

This edition is created in India for free distribution in India.

This edition is published by Springer Nature India Private Limited.
Registered Office: 7th Floor, Vijaya Building, 17, Barakhamba Road, New Delhi 110 001, India.
T: +91 (0) 11 4575 5888
www.springerhealthcare.com

Part of the Springer Nature group

Contents

Technical Innovations

1. **Laparoscopic Vesico-Ureteral Reimplantation with Lich–Gregoir Approach in Children: Medium Term Results of 159 Renal Units in 117 Children** **1**
   Victor Soulier, Aurélien Scalabre, Manuel Lopez, *et al*.

2. **Long-term Outcomes of Ultrasound-guided Percutaneous Nephrolithotomy in Patients with Solitary Kidneys: A Single-Center Experience** **13**
   Boxing Su, Wenyi Liang, Weiguo Hu, *et al*.

Practical Tips in Urology

3. **To Dust or Not To Dust: A Systematic Review of Ureteroscopic Laser Lithotripsy Techniques** **24**
   Javier E. Santiago, Adam B. Hollander, Samit D. Soni, *et al*.

4. **Cystoscopic Ureteral Stent Placement: Techniques and Tips** **38**
   Brian J. Linder, John A. Occhino

Case Setup

5. **A Large Bladder Stone Caused by the Intravesical Migration of an Intrauterine Contraceptive Device: A Case Report** **42**
   Victor Soulier, Aurélien Scalabre, Manuel Lopez, *et al*.

Laparoscopic Vesico-Ureteral Reimplantation with Lich–Gregoir Approach in Children: Medium Term Results of 159 Renal Units in 117 Children

Victor Soulier[1], Aurélien Scalabre[2], Manuel Lopez[2], Chi-Ying Li[3], Sodara Thach[1], Sophie Vermersch[2], François Varlet[2]

Abstract

Purpose: Vesico-ureteral reflux (VUR) represents one of the most significant risk factors for acute pyelonephritis in children. Surgery is an important part of its management. Laparoscopic ureteric reimplantation using the Lich–Gregoir technique is an option for VUR. The aim of this study is to assess short- and medium-term outcomes of this approach.

Materials and Methods: This is a retrospective study including all children with VUR treated by laparoscopic extravesical ureteral reimplantation with the Lich–Gregoir technique in University Hospital of Saint-Etienne from August 2007 to May 2016. Surgery was performed after the age of 12 months in cases with repeated urinary tract infection (UTI) and a deterioration of renal function. All patients were followed-up post operatively.

Results: 117 children (92 girls, 25 boys) representing 159 renal units were included. The mean age at surgery was 47.1 months (±32.7 months). The mean follow-up was 59.3 months (±31 months). The resolution rate for VUR in terms of no febrile UTIs was 98.3%. The mean operative time was 96 min (±37.7 min) for unilateral procedures and 128 min (±46.1 min) for bilateral procedures. The mean hospital stay was 25.3 h (±6.3 h). There was no difference between males and females regarding age, weight, renal function or follow-up duration.

Electronic supplementary material The online version of this article (doi:10.1007/s00345-017-2064-y) contains supplementary material, which is available to authorized users.

Victor Soulier (✉)
e-mail: victorsoulier@gmail.com
[1]Urology Department, University Hospital of Saint Etienne, Avenue Albert Raimond, 42055 Saint Etienne Cedex 2, France
[2]Paediatric Surgery Unit, University Hospital of Saint Etienne, Avenue Albert Raimond, 42055 Saint Etienne Cedex 2, France
[3]FRCS(Urol), University College of London Hospital of London, London NW12SH, UK

Conclusions: Laparoscopic reimplantation with Lich–Gregoir technique is an efficient, quick and safe technique for the management of VUR. The success rate is comparable to open techniques with the advantages of laparoscopic approach; this can potentially be performed as a Day Case procedure.

Keywords Laparoscopy, Vesico-ureteral reflux, VUR, Lich–Gregoir, Children

Introduction

Vesico-ureteral reflux (VUR) represents one of the most significant risk factors for acute pyelonephritis in children. Surgery is an important part of its management [1]. Ureteral reimplantation is an effective treatment of high-grade VUR [2]. Open procedures such as Cohen technique are the current gold standard with a success rate over 98% [3]. However, minimally invasive techniques such as endoscopic, laparoscopic or robotic approaches are promising alternatives [4].

Purely laparoscopic reconstructive surgery can be technically challenging, even for experienced laparoscopic surgeons. Efforts have been directed towards reducing the perioperative morbidity and the duration of hospitalization. The aim of this study is to report our experience in the treatment of VUR using laparoscopic extravesical ureteral reimplantation according to Lich–Gregoir technique.

Materials and Methods

We retrospectively reviewed the medical charts of all children treated for VUR including those who underwent laparoscopic extravesical ureteral reimplantation with the Lich–Gregoir technique in our institution from August 2007 to May 2016.

Inclusion criteria were: age between 1 and 18 years at the time of surgery, diagnosis of VUR, patients operated by laparoscopic extravesical ureteral reimplantation with the Lich–Gregoir technique and minimal follow-up of 6 months.

The severity of VUR was evaluated on the results of the voiding cystourethrogram (VCUG) using the international classification (grade I to V) [5]. Differential renal function was evaluated by dimercaptosuccinic acid (DMSA) scintigraphy preoperatively, 3 months at least after the last UTI. The indications for surgery were, as recommendations from the American Urological Association (AUA): high grade reflux ≥III with deterioration of renal function or recurrence of acute pyelonephritis despite antibiotic prophylaxis [6]. Presence of anatomical disorders was noticed (duplicated systems, Hutch diverticulum).

In cases of severe reflux (grade III or more) with a deterioration of renal function on isotope renography, a laparoscopic procedure was performed after the age of 12 months. A thorough post-operative follow-up was performed consisting of a renal and bladder ultrasonography at 1, 3, 6, 12, 24 months and subsequently longer intervals. No additional imaging was routinely done for asymptomatic patients. Success outcome of the procedure was defined as absence of febrile urinary tract infection during follow-up. We decided to exclude of this study children with mega-ureters we operated (7 in total), we considered relative value unit (RVU) and mega-ureters to be different condition and mixing them in the same study could be confusing.

The laparoscopic technique was previously described by Riquelme *et al.* article [7]. Figure 1 presents the surgeon, 1st assistant and nurse positions during the procedure. Figure 2 shows the per-operative aspect of a right re-implanted ureter in a 2-year-old male patient. Using R-statistics software, we performed a Student's t test and Fischer's exact tests to compare results in males and females. We applied a Bonferroni correction to adjust the p-value to multiple statistic tests (corrected p value <0,05 was considered statistically significant).

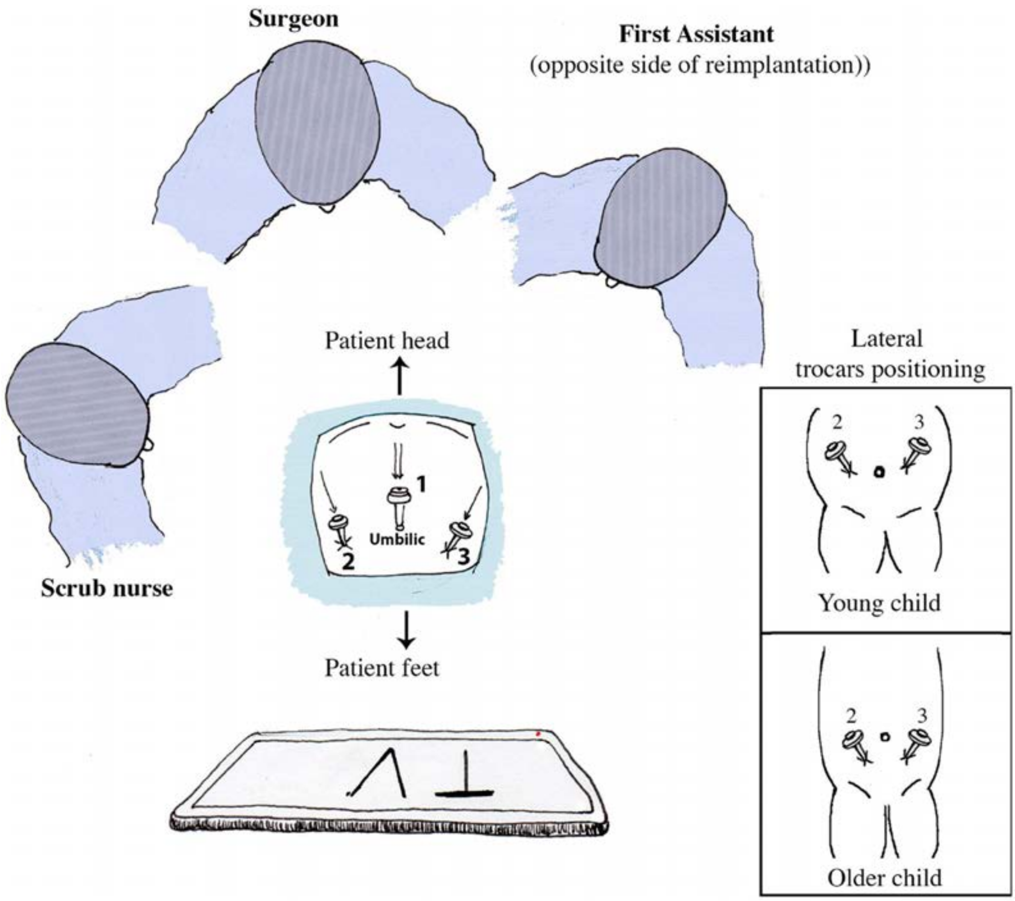


Fig. 1: Surgeon, first-assistant, scrub nurse and trocars positioning: example of an extra-vesical laparoscopic right reimplantation with Lich– Gregoir approach.

Fig. 2: Per-operative aspect of reimplanted right ureter in a 2-year-old boy.

Results

In total 117 children (92 girls, 25 boys) with VUR operated by laparoscopic extravesical ureteral reimplantation with the Lich–Gregoir technique were included.

We observed 23 renal units with VUR grade I–II and 136 renal units with VUR grade ≥III. The mean age at surgery was 47.13 months (±32.7 months). The mean follow-up was 59.3 months (±31 months) and the mean weight was 17.11 kg (±8.4 kg). Mean differential renal function was 36.9% (±16.1%) for unilateral reflux. There were no significant difference between males and females regarding age, weight, DMSA or follow-up duration. There was no statistically significant difference considering grades of VUR between females and males, clustered in grade I–II and grade III–V using AUA model (p = 0,37, IC95% [0.52; 22.03]).

We performed 49 bilateral and 61 unilateral reimplantations (Table 1). Fifteen bilateral VUR with low grade on one side (fourteen grade I and one grade II) and a high grade on the other side were treated by endoscopic sub-ureteral injection and a laparoscopic reimplantation, respectively, during the same procedure. Eight patients (five females, three males) had Hutch diverticulum treated by doing a precautionary suture in the lower part of the bladder channel, twenty-eight patients had VUR in the lower pole of a duplicated collecting system (DCS) including five bilateral VUR. Three patients with ureteroceles and destructed renal upper pole had upper polar hemi-nephrectomy during the same procedure. In two cases, a contralateral total nephrectomy was performed in the same operative time for atrophic and non-functional kidneys.

The mean operative time was 96 min (±37.7 min) for unilateral reimplantation and 128 min (±46.1 min) for bilateral reimplantation. Four unilateral VUR were discharged 8 h after surgery. The mean hospital stay was 25.3 h (±6.3 h). One-third of these procedures were performed by a resident or a registrar under supervision of an experienced surgeon.

The resolution rate, in terms of no further febrile UTIs accounted to 98.3% (115/117 patients). Nevertheless, we observed an asymptomatic VUR grade I in a child who had a postoperative

Table 1: Characteristics, statistic analysis and results in our series.

	Girls	Boys	
Population	92 (78.6%)	25 (21.4%)	
Age (months)	49.6 (±33.1)	38.1 (±32.7)	$p = 0.14$; IC95% [–3.65; 25.63]
Weight (kg)	17.5 (±8.4)	15.6 (±8.6)	$p = 0.34$; IC95% [–1.90; 5.50]
%DMSA (unilateral VUR)	37.8 (±9.0)	33.6 (±18.0)	$p = 0.27$; IC95% [–3.48; 11.81]
Follow-up (months)	59.2 (±30.9)	59.5 (±31.3)	$p = 0.16$; IC95% [–46.56; 1.32]
Right VUR	7	3	
Left VUR	41	10	
Bilateral VUR	42	7	
Number of renal unit (R.U.)	132	27	
Grade 1 (endoscopic treatment)	15 (11.4%) 15	0 0	
Grade 2 (endoscopic treatment)	6 (4.5%) 1	2 (7.4%) 0	
Grade 3	56 (42.4%)	10 (37.0%)	
Grade 4	53 (40.2%)	13 (48.1%)	
Grade 5	2 (1.5%)	2 (7.4%)	
Low and high grade			
Grade 1–2	21	2	
Grade 3–5	111	25	$p = 0.37$; IC95% [0.52; 22.03]
Duplicated collecting systems	24	4	
Hutch diverticulums	5	3	
Ureterocele endoscopic incision	4	0	
Average operating time (min)			
Unilateral reflux			
Right	82.85 (±38.8)	103.3 (±28.87)	$p = 0.36$; IC95% [–76.67; 35.72]
Left	96.03 (±34.2)	104.2 (±39.06)	$p = 0.56$; IC95%[–37.39; 21.04]
Bilateral reflux	125.43 (±48.8)	147.14 (±29.28)	$p = 0.13$; IC95%[–50.77; 7.34]
Complications			
Mucosa perforation	5	0	
Supra pubic catheter insertion	0	1	For 10 days
Ureteral fistula	2	0	J7 and J15 post-operative, respectively
Reimplantation failure	1	1	
Cured by open procedure (Cohen)	0	1	Grade 2, 1 year after surgery, confirmed by VCUG
Cured by endoscopic injection of deflux®	1	0	Grade 1

VCUG after the laparoscopic reimplantation procedure; we just followed-up him and he never experienced urinary tract infection.

Early Complications

In 5 cases, a mucosal perforation occurred during the detrusorotomy, treated immediately by an endo-loop repair. One temporary urinary retention occurred after a bilateral reimplantation. The patient had supra-pubic pain and no urine in the nappy 6 h after the procedure. A supra-pubic catheter was placed under general anesthesia and removed 10 days later with uneventful recovery. Two patients needed reintervention for a uretero-peritoneal fistula 7 and 15 days after surgery. One was treated by Cohen procedure and one by removing two stitches of the reimplantation with ureteral suturing and double J stent.

We observed two VUR recurrences; both were revealed by pyelonephritis recurrence and confirmed by VCUG. We decided to treat the first one by an open Cohen procedure (VUR grade II), and the other by endoscopic injection of Deflux® (VUR grade I). These complications are summarized in Table 2.

Late Complications

During follow-up, 17 children had a lower urinary tract infection and 3 an asymptomatic bacteriuria (14 girls, 3 boys), treated by oral antibiotics. They were all treated for constipation by a multidisciplinary approach including dietetic information, laxatives and physiotherapy. Eighteen

Table 2: Early complications encountered in our series according to Clavien–Dindo classification system.

Grade	Definition	Patient (*n*)
I	Any deviation from normal post-operative course without pharmacological	0
II	Requiring pharmacological treatment other than such allowed for grade I	0
IIIa	Requiring intervention non under GA	1 (Bladder retention with necessity of supra-pubic catheter)
IIIb	Requiring intervention under GA	2 ureteral fistulas
		2 persistent VUR (1 treated by Cohen procedure, 1 by bulking agent)
IVa	Life threatening complications with single organ dysfunction	0
IVb	Life threatening complications with multi-organ dysfunction	0
V	Death of the patient	0
Suffix "d"	If the patient suffers from a complication at the time of discharge, suffix "d" is added to the respective grade of complication	

Clavien–Dindo classification of surgical complications patients were also treated for functional urinary disorders (Table 3). There was no other late complication.

Discussion

VUR management is controversial; some specialists recommend complete and long-term medical treatment and surgery is only indicated in case of force-majeure while others prefer to adopt a more proactive surgical approach. There is no strong consensus about prophylactic antibiotic treatment, operative indications, age of surgery or follow-up management [2, 6].

The mean age at surgery in the present series was 46.4 months, which is comparable to other reported series [7, 8]. It seems important to perform surgery after the age of 12 months, when bladder-nerves and functional structures growth is sufficient [2].

According to AUA recommendations [6] we decided to operate on children with grade III VUR or more, with renal dysfunction (DMSA < 40%) or renal scarring demonstrated on isotope renography or children developing recurrent pyelonephritis despite optimal medical treatment. We performed endoscopic injection of bulking agent for low grade VUR in accordance with the literature [9, 10] which is a reasonable alternative to open surgical reimplantation, although long-term results at adulthood remain unknown.

When surgery is indicated, open surgery remains the gold standard for ureteral reimplantation with good long- term results (success rate over 98%) [11]. The goal of any anti-reflux procedure is to restore anti-refluxing mechanism of the ureterovesical junction [12]. Lich–Gregoir technique was described by Lich and Gregoir in 1961 and 1964, respectively [13, 14]. The Lich–Gregoir technique is associated with a high success rate [4, 15] and extra-vesical reimplantation has been associated with reduced morbidity in comparison with intravesical techniques such as Cohen's procedure [4]. However, reported incidence of urinary retention and impaired voiding efficiency are 8–15% after bilateral extravesical reimplantation by open approach [16, 17]. This might be a result of neurovascular injury during wound handling and ureteral or bladder dissection [17]. A nerve-sparing technique proposed by David in 2004 allows to reduce this

Table 3: Post-operative infectious issues and urinary tract infection in our series.

	Number of children
Infectious issues	
Asymptomatic bacteriuria	3
Lower urinary tract infection	17
Upper urinary tract infection	0
Constipation management	23
Urinary Tract dysfunction	18
Overactive bladder	6
Noctural enuresia	5
Detrusor sphincter dyssynergia	7

complication (2% of transitory bladder retention) [17]. Casale *et al.* in 2008 reported a series of 41 patients, who underwent nerve-sparing extravesical reimplantation by robotic approach, respectively, for bilateral VUR, without episodes of urinary retention. The authors attributed the absence of retention to improved visualization of the neurovascular bundle lateral to the ureteral hiatus [18] compared with open procedures. A recent series of pediatric robotic extravesical ureteral reimplantation using the same technique reported an incidence of 30% of postoperative voiding difficulties in bilateral cases [19]. In 2012, Baynes *et al.* reported the largest cohort of patients undergoing extravesical ureteral reimplantation by laparoscopy with Lich–Gregoir technique in the literature with an incidence of urinary retention of 6.5% after bilateral reimplantation [20]. Esposito *et al.* [4] described a 1.33% rate of urinary retention in open-Cohen procedures; Herz *et al.* [21] reported a 0 and 5.6% of temporary urinary retention for unilateral and bilateral, respectively, robot-assisted reimplantation. Although the incidence of urinary retention was much lower in this study (0, 8%), there is certainly a real risk of voiding difficulty. In the present series, only one patient presented with a transitory bladder emptying difficulty after a bilateral reimplantation. He required a suprapubic catheter under local anesthesia for 10 days (Clavien IIIa). We agree that lateral dissection of the ureter and bladder should be limited to avoid damage to pelvic nerves [18] and we recommend a gentle and soft tissue dissection around the lower ureteral part and no extensive coagulation. We decided to perform a laparoscopic approach of vesicoureteric reimplantation with Lich–Gregoir technique for several reasons. We consider it as minimally invasive, meaning a surgical approach which allows good functional results, comparable to open techniques, with some other advantages, such as lower pain, shorter recovery and hospital stay, acceptable cosmetic results. We make three small incisions, one of 5 mm-diameter (open-coelis-copy and video-camera) and 2 of 3 mm-diameter (for instruments). We use the open-laparoscopy principle to avoid the dreadful laparoscopic complications (visceral and vascular injuries, not observed in our center after more than 4000 procedures). We use a 10 mmHg CO_2 insufflation pressure for all of our patients and we did not observe anesthesiological complications during our laparoscopic surgeries. Furthermore, this approach allows us to get a very good vision of the posterior bladder wall during the dissection and Lich–Gregoir procedure. All our laparoscopic interventions are video-recorded, which help us to share our experience and techniques with our students, residents and colleagues. We also reanalyze and criticize our procedures a posteriori and to improve our technique when we front complications.

We observed two febrile VUR recurrences in our series (Clavien IIIb), that is to say 1.36% of failure revealed by febrile UTI. One was treated by injection of bulking agent and the other one by open-Cohen technique. This result is comparable with the literature; Bayne *et al.* [20] reported a 1.02% of VUR recurrence for laparoscopic procedures; Esposito *et al.* [4] observed a 6.66% VUR recurrence in open Cohen procedures, whereas Kasturi [22] and Herz [21] showed, respectively, 0.6 and 2.8% of VUR recurrence for robot-assisted procedures.

Lich–Gregoir laparoscopic technique has significant advantages [4, 15]. Esposito *et al.* compared laparoscopic approach with open Cohen technique and showed that hospitalization was shorter in the laparoscopic group (2.42 days ± 0.86 vs 12.58 days ± 4.26 in the Cohen group, $p = 0.03$), use of painkillers was shorter (1.30 days ± 0.59 vs 4.83 days ± 2.87 for Cohen group,

$p = 0.001$) with a postoperative VAS score between 0 and 3 for all laparoscopic patients. Bladder catheters were less frequent in the laparoscopic group (26.6% vs 90% for Cohen group, $p = 0.001$). In our opinion, no bladder catheter is needed during the post-operative period. The mean operative time for unilateral reimplantation was 96 min (±37.7 min) and 128 min (±46.1) for bilateral procedure, which is comparable to literature data [4, 20]. In addition, decreased hospital stay with faster recovery allows this surgery to be performed as a day-case [8]. Our median hospital stay was 25.3 h (11–48); the last four patients who presented unilateral VUR were operated on and went back home the same day (median hospital stay was 8 h (7–10 h)). The laparoscopic extravesical reimplantation of the ureter has a certain learning curve but is easily feasible and well-standardized. In our series registrars or residents, under senior control, made one-third of procedures. We decided not to compare inter-operators time of procedure to represent the "real-life" of our theater room. A study is necessary to describe the learning curve of this procedure. Even if we cannot exclude that laparoscopic skills certainly influence dexterity or the operating time, we have the feeling that this procedure is technically reproductible, even for young surgeons as far as they are involved in laparoscopic procedures. We strongly believe in this technique and try to diffuse it because of its reproducibility. We try to elaborate a laparoscopic simulator of this technique, which allows motivated surgeons to be trained in the future, or so we hope.

We decided to consider the operative success as the absence of recurring febrile urinary tract infection, which is for us clinically pertinent. We did not perform other imaging routinely in asymptomatic children with normal renal ultrasound [8, 21, 22]. Several authors showed that routine postoperative VCUG and renal functional studies are not mandatory in asymptomatic patients [23, 24] because no correlation was shown between a persistent postoperative VUR and the risk of febrile urinary tract infection. In our institution, post-operative VCUG was only performed at the beginning of our experience to set our technique up.

Extravesical robotic-assisted laparoscopic ureteral reimplantation (RALUR) is an alternative to open and laparoscopic surgery. This approach has been described in 2010 by Sorensen *et al.* [25] in 50 children (mean age: 8.6 years old). Smith *et al.* in 2011 [19] compared open-technique to robotic approach with a high success rate (97%, mean age: 69 months). A recent retrospective analysis published in 2016 by Herz *et al.* [21] presents results of children who underwent unilateral (RALUUR) or bilateral (RALBUR) laparoscopic robotic-assisted ureterovesical reimplantation. Surgical success was higher for unilateral (91.7%) in comparison with bilateral reimplantation (72.2%). Mean age was 5.2 years (range 2.5–13.1). Mean operative time was 206.5 min (range: 145–256 min) and 306.2 (range: 229–444 min) for unilateral and bilateral reimplantation, respectively. Trocars size were 12 mm (61.1%) or 8.5 mm (38.9%) for camera and 8 mm (77.8%) or 5 mm (22.2%) for instruments, with the presence of 5 mm-assistant trocars in two-third of the procedures. In the present study, Lich–Gregoir procedures were performed under laparoscopy using a 5 mm optic trocar and two 3 mm instrumental trocars. We strongly believe that robotic surgery has many advantages: viewing quality, high precision of motion, but larger trocars size can be a break even if incidence of port-site complications remains low (0, 83%) [26]. Moreover, operative time is significantly longer in robotic-assisted ureteral reimplantation, which has to be taken into consideration for anesthesiologists and operating theater team.

One of the most common operative complications in laparoscopic extravesical ureteral reimplantation is ureteral injury or obstruction (ischaemia) owing to excessive handling of the ureter or an excessive closure of the new channel [7]. Lakshmanan and Kasturi in 2000 and 2012, respectively [22, 27], reported 6.3% (3/47) and 0.6% (1/150) intra-abdominal urinary leak requiring drainage and bilateral pigtail stents for 2 months. Bayne *et al*. observed a 2.04% rate of ureteral leakage [20] and Esposito *et al*. showed a 1.33% of the same complication in open Cohen procedures [4]. The common symptoms and signs of these patients are: mild to severe abdominal, flank or back pain, fever, vomiting, urinary leakage, haematuria, and leukocytosis. Physical examination may reveal a tender, distended abdomen and sometimes signs of peritoneal irritation. In contrast to the often delayed presentation, a ureteral injury resulting in a urinoma (extravasation of urine which may collect at different sites, depending on the location of injury) can be quickly diagnosed on ultrasound-scan or on CT-scan, [28]. These imaging studies are valuable in the diagnosis and management of complications after laparoscopic urologic surgery. At the beginning of our series, two patients presented with a ureteral perforation at 7 and 15 days postoperative, respectively (Clavien IIIb). A distal ureteral injury was diagnosed on CT scan. We performed an open reimplantation for the first patient with Cohen technique and a redo laparoscopic procedure for the second patient, requiring drainage pigtail stent. In these two cases, we founded a urinoma and a ureteral perforation at the distal part of the ureter. We reviewed the surgery video but did not find the traumatic cause for this perforation. We assume that the probable causes were due to ischaemia caused by excessive handling of the ureter, a burn with the diathermy hook dissection or an excessive closing of the new tunnel. To avoid this complication we opted to wrap a soft band around the ureter for manipulation and limit the amount and duration of cautery. Another probable intraoperative complication is the risk of visceral organ injury and postoperative bowel adhesion. Fortunately, these complications have not been observed in our series or in the literature.

We observed in our series 17 children who suffered from lower urinary tract infections (Clavien II), representing 14.5%, which is comparable with robotic-reimplantation data 5.5–11% for Herz *et al*. [21] in extravesical approach and up to 9% for open-Cohen approach [4]. We cannot exclude that this urinary tract infection could be linked with nerve damage during dissection. We noticed that all these children were constipated and could also explain the urinary emptying issues. We attach great importance to intestinal transit in these patients since we know the urinary and intestinal systems strong interactions.

Refluxing DCS associated with obstruction, VUR or both, can be managed by laparoscopic approach in a one-stage procedure involving upper and/or lower urinary tract. In our series, refluxing DCS was associated with obstruction in 4 of 28 patients. Three had ectopic intravesical ureterocele with complete deterioration of the upper kidney function. Upper hemi-nephro-ureterectomy, excision of the ureterocele and ureteric reimplantation were done during the same procedure. Thakre *et al*. also reported that laparoscopic hemi-nephro-ureterectomy with excision of ureterocele and ureteric reimplantation can be safely and effectively performed in a single-stage laparoscopic procedure. The procedure minimises the need of traditional open surgery and its consequences in patients with refluxing DCS associated with ureterocele and complete deterioration of upper moiety function and VUR [29].

Even if our results seem promising, the retrospective and monocentric nature of the study certainly limit them. Multi-centric and prospective series with long-term follow-up are needed to confirm the effectiveness of this approach.

Conclusion

Laparoscopic extravesical ureteral reimplantation with the Lich–Gregoir technique is a safe, effective, and feasible procedure for the treatment of VUR in children with good initial and medium-term results comparable to open procedures, with a low morbidity and good resolution of VUR. This series is one of the largest available in pediatric surgery literature. The technique results in short hospital stay and reduced recovery period can be applied to unilateral VUR, bilateral VUR and duplex system. We did not observe postoperative bladder dysfunction even after bilateral reimplantations. This procedure should become an established treatment option.

Authors' contribution VS Project development, data collection and management, data analysis manuscript writing and editing AS project development, data management, manuscript writing and editing ML Project development, data collection and management, manuscript editing CYL data analysis manuscript editing ST data analysis manuscript editing SV manuscript editing FV project development, data management, data analysis manuscript writing and editing.

Compliance with Ethical standards

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

Ethical responsibilities of the authors The authors declare that the manuscript has not been submitted to more than one journal for simultaneous consideration. It has not been published previously (party or full). No data have been fabricated or manipulated to support our conclusions. Authors whose names appear on the submission have contributed sufficiently to the scientific work.

Research involving human participants For this type of study (retrospective study), formal consent is not required.

References

1. Olbing H, Claësson I, Ebel KD, Seppänen U, Smellie JM, Tamminen-Möbius T *et al.* (1992) Renal scars and parenchymal thinning in children with vesicoureteral reflux: a 5-year report of the International Reflux Study in Children (European branch). J Urol 148(5 Pt 2):1653–1656
2. Demède D, Cheikhelard A, Hoch M, Mouriquand P (2006) Médecine factuelle et reflux vésico-urétéral. EMC Urol doi:10.1016/S0000-0000(06)40852-4
3. Paquin AJ (1959) Ureterovesical anastomosis: the description and evaluation of a technique. J Urol 82:573–583.
4. Esposito C, Escolino M, Lopez M, Farina A, Cerulo M, Savanelli A *et al.* (2016) Surgical management of pediatric vesicoureteral reflux: a comparative study between endoscopic, laparoscopic, and open surgery. J Laparoendosc Adv Surg Tech 26(7):574–580.
5. Lebowitz RL, Olbing H, Parkkulainen KV, Smellie JM, Tamminen-Möbius TE (1985) International system of radiographic grading of vesicoureteric reflux. International Reflux Study in Children. Pediatr Radiol 15(2):105–109.
6. Peters CA, Skoog SJ, Arant BS, Copp HL, Elder JS, Hudson RG *et al.* (2010) Summary of the AUA guideline on management of primary vesicoureteral reflux in children. J Urol 184(3):1134–1144.
7. Riquelme M, Lopez M, Landa S, Mejia F, Aranda A, RodarteShade M *et al.* (2013) Laparoscopic extravesical ureteral reimplantation (LEVUR): a multicenter experience with 95 cases. Eur J Pediatr Surg 23(2):143–147.

8. Wicher C, Hadley D, Ludlow D (2010) 250 consecutive unilateral extravesical ureteral reimplantations in an outpatient setting. J Urol 184(1):311–314.
9. O'Donnell B, Puri P (1984) Treatment of vesicoureteric reflux by endoscopic injection of Teflon. Br Med J Clin Res Ed. 289(6436):7–9.
10. Hayn MH, Smaldone MC, Ost MC, Docimo SG (2008) Minimally invasive treatment of vesicoureteral reflux. Urol Clin North Am 35(3):477–488.
11. Barrou B, Bitker MO, Chatelain C (1990) Réimplantations urétéro-vésicales anti-reflux. EMC Tech Chir—Urol 41:133
12. Trial Investigators RIVUR, Hoberman A, Greenfield SP, Mattoo TK, Keren R, Mathews R *et al.* (2014) Antimicrobial prophylaxis for children with vesicoureteral reflux. N Engl J Med 370(25):2367–2376
13. Lich R, Howerton LW, Davis LA (1962) Ureteral reflux, its significance and correction. South Med J 55:633–635.
14. Gregoir W (1964) The surgical treatment of congenital vesicoureteral reflux. Acta Chir Belg 63:431–439.
15. Palmer JS (2008) Extravesical ureteral reimplantation: an outpatient procedure. J Urol. 180((4 Suppl)):1828–1831 (discussion 1831).
16. Fung LC, McLorie GA, Jain U, Khoury AE, Churchill BM (1995) Voiding efficiency after ureteral reimplantation: a comparison of extravesical and intravesical techniques. J Urol 153(6):1972–1975.
17. David S, Kelly C, Poppas DP (2004) Nerve sparing extravesical repair of bilateral vesicoureteral reflux: description of technique and evaluation of urinary retention. J Urol 172((4 Pt 2)):1617– 1620 (discussion 1620).
18. Casale P, Patel RP, Kolon TF (2008) Nerve sparing robotic extravesical ureteral reimplantation. J Urol 179(5):1987–1989 discussion 1990.
19. Smith RP, Oliver JL, Peters CA (2011) Pediatric robotic extravesical ureteral reimplantation: comparison with open surgery. J Urol 185(5):1876–1881.
20. Bayne AP, Shoss JM, Starke NR, Cisek LJ (2012) Single-center experience with pediatric laparoscopic extravesical reimplantation: safe and effective in simple and complex anatomy. J Laparoendosc Adv Surg Tech A. 22(1):102–106.
21. Herz D, Fuchs M, Todd A, McLeod D, Smith J (2016) Robotassisted laparoscopic extravesical ureteral reimplant: a critical look at surgical outcomes. J Pediatr Urol 12(6):402-e1–402-e2.
22. Kasturi S, Sehgal SS, Christman MS, Lambert SM, Casale P (2012) Prospective long-term analysis of nerve-sparing extravesical robotic-assisted laparoscopic ureteral reimplantation. Urology. 79(3):680–683.
23. Falkensammer ML, Gobet R, Stauffer UG, Weber DM (2008) To Cohen and forget? Evaluation of postoperative imaging studies after transtrigonal ureteric reimplantation for vesicoureteric reflux in children. Urol Int 81(2):218–221
24. Grossklaus DJ, Pope JC, Adams MC, Brock JW (2001) Is postoperative cystography necessary after ureteral reimplantation? Urology. 58(6):1041–1045.
25. Sorensen MD, Johnson MH, Delostrinos C, Bice JB, Grady RW, Lendvay TS (2010) Initiation of a pediatric robotic surgery program: institutional challenges and realistic outcomes. Surg Endosc 24(11):2803–2808.
26. Tapscott A, Kim SS, White S, Graves R, Kraft K, Casale P (2009) Port-site complications after pediatric urologic robotic surgery. J Robot Surg. 3(3):187.
27. Lakshmanan Y, Fung LC (2000) Laparoscopic extravesicular ureteral reimplantation for vesicoureteral reflux: recent technical advances. J Endourol 14(7):589–593 (discussion 593–4).
28. Lopez M, Varlet F (2010) Laparoscopic extravesical transperitoneal approach following the Lich–Gregoir technique in the treatment of vesicoureteral reflux in children. J Pediatr Surg 45(4):806–810.
29. Lopez M, Melo C, François M, Varlet F (2011) Laparoscopic extravesical transperitoneal approach following the Lich–Gregoir procedure in refluxing duplicated collecting systems: initial experience. J Laparoendosc Adv Surg Tech A 21(2):165–169.

Source: Soulier, V., Scalabre, A., Lopez, M. *et al. World J Urol.* (2017) 35: 1791. https://doi.org/10.1007/s00345-017-2064-y.

Long-term Outcomes of Ultrasound-Guided Percutaneous Nephrolithotomy in Patients With Solitary Kidneys: A Single-Center Experience

Boxing Su[1], Wenyi Liang[2], Weiguo Hu[1], Bo Xiao[1], Xin Zhang[1], Song Chen[1], Yuzhe Tang[1], Yubao Liu[1], Meng Fu[1], Wenjie Bai[1], Jianxing Li[1]

Abstract

Purpose: To report our experience with total ultrasound-guided percutaneous nephrolithotomy (PCNL) in the management of patients with solitary kidney, and evaluate the safety and feasibility of this technique.

Materials and Methods: Between October 2014 and December 2016, 48 patients with solitary kidneys underwent total ultrasound-guided PCNL at our institution. Stone-free rate (SFR), auxiliary procedures, and complications were recorded. Changes in renal function were evaluated by comparing preoperative and postoperative estimated glomerular filtration rates (eGFRs). Perioperative factors that may affect renal function were analyzed to define factors predicting renal function improvement on long-term follow-up. Of 48 patients, 44 were followed at least 6 months, whereas four patients were lost to follow-up.

Results: Among all patients, staghorn calculi were found in 18 (37.5%) patients. 14 (29.2%) patients required a two-stage PCNL. Struvite was found in six (12.5%) patients. Complications were reported in eight (16.7%) patients. Severe bleeding was noticed in three patients; no angioembolization was required. After a median follow-up of 12 (6–26) months, the final SFR was 81.8% after auxiliary treatments. There was a significant improvement of eGFR from 53.9 ± 24.0 to 61.3 ± 25.4 mL/min/1.73 m^2 ($P < 0.01$). Renal function was stable, improved and worse in 65.9%

Electronic supplementary material The online version of this article https://doi.org/10.1007/s00345-018-2458-5) contains supplementary material, which is available to authorized users.

Jianxing Li (✉)
e-mail: ljx1@sina.com
Extended author information available on the last page of the article

(*n* = 29), 27.3% (*n* = 12), and 6.8% (*n* = 3) of patients, respectively, compared with preoperative levels.
Conclusions: Ultrasound-guided PCNL is a safe and feasible procedure with an acceptably low complication rate in patients with solitary kidneys. At long-term follow-up, the renal function in more than 90% of the patients with solitary kidneys can be improved or stabilized after ultrasound-guided PCNL.

Keywords Ultrasound guidance, PCNL, Solitary kidney

Abbreviations

PCNL	Percutaneous nephrolithotomy
SFR	Stone-free rate
eGFR	Estimated glomerular filtration rate
CKD	Chronic kidney disease
MS	Metabolic syndrome
CIRFs	Clinically insignificant residual fragments
RIRS	Retrograde intrarenal surgery
DM	Type 2 diabetes mellitus

Introduction

Percutaneous nephrolithotomy (PCNL) is the standard treatment approach for large and complex renal calculi. High stone-free rates of greater than 90% have been reported [1]. However, there are risks of complications such as uncontrollable bleeding that may necessitate embolization or even a nephrectomy [2]. Therefore, PCNL for the treatment of stones in a solitary kidney still represents a special operative challenge.

Another main concern when performing PCNL in solitary kidneys was the long-term effect of percutaneous surgery on renal function [3]. However, it is difficult to evaluate this effect accurately due to the influence of the contralateral kidney. Therefore, the solitary kidney represents an appropriate model in which to study the impact of PCNL on renal function and find out the underlying factors correlated with renal function improvement or deterioration.

There are many reports that addressed the issue of PCNL in management of stones in a solitary kidney [4]. However, most of them were under fluoroscopic guidance. Access for PCNL under total ultrasound guidance has been increasingly demonstrated as an acceptable alternative to fluoroscopy [5]. However, its safety and effectiveness have never been reported in the solitary kidneys.

In the present study, we reported our experience with total ultrasound-guided PCNL in the treatment of patients with solitary kidneys, evaluated its outcomes, complications, and investigated factors affecting renal function changes after long-term follow-up.

Materials and Methods

We retrospectively reviewed the records of 48 patients who underwent PCNL for stones in a solitary kidney at our institution between October 2014 and December 2016. No patient in our study underwent routine dialysis. Seven patients had a congenital solitary kidney (14.6%), 12 patients had a previous contralateral nephrectomy (25%), and 29 patients had a solitary functioning kidney with contralateral atrophy (60.4%). Non-functional contralateral kidneys were confirmed by Tc-99 m-DTPA renography. Patient demographic characteristics, including gender, age, the presence of type 2 diabetes mellitus (DM) and hypertension, body mass index (BMI), as well as previous ipsilateral kidney open surgery were recorded. Preoperative laboratory tests included serum creatinine, fasting glucose, triglyceride, total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol levels, serum uric acid, liver function tests, complete blood count, coagulation screen tests, and urine cultures. Eighteen patients with positive preoperative urine cultures were treated according to antibiotic sensitivity tests. Preoperative nephrostomy was performed in five patients (10.4%) to relieve anuria and infection due to obstruction. Only the nadir serum creatinine after relief of obstruction was used for calculation of preoperative eGFR. Two patients with concurrent ureteral stones were initially treated with ureteroscopy. Stones were classified as complex (renal caliceal stones with pelvis stones, partial or complete staghorn stones,) or simple (isolated renal caliceal or pelvis stones), regardless of their size. Metabolic syndrome (MS) was diagnosed according to NCEP ATP-III criteria (2005 revision) [6].

Technique

A retrograde 5F ureteric catheter was inserted into the renal pelvis with the patient in lithotomy position and renal access achieved with the patient prone. Access to the selected calyx was achieved under ultrasound guidance (3.5 MHz probe, LOGIQ e, GE Healthcare, USA) using a 17.5-gauge coaxial needle targeting its fornix, as we described in detail previously [7]. The tract was dilated with serial or balloon dilators (X Force® N30 balloon dilator, Bard Urological, Covington, Georgia) up to 24F under X-ray-free condition. The "two-step" method was used for serial dilation [7], and the process of balloon dilation was monitored under real-time ultrasound guidance (Supplementary material). Fragmentation of the stones was accomplished using an ultrasonic lithotripter or pneumatic lithotripter (Swiss Lithoclast, EMS Electro Medical Systems, Nyon, Switzerland) under a rigid nephroscope. Ultrasonography for residual stones was conducted to define whether additional tracts were needed. At the conclusion of the procedure, a 6F stent was inserted antegrade into the ureter and 14Fr nephrostomy tube was placed within the renal pelvis or the involved calyx. A plain X-ray of the kidneys, ureters, and bladder (KUB) was obtained 48 h after the operation. The nephrostomy tube was removed when the urine ran clear or during the next stage of surgery. SWL, retrograde intrarenal surgery (RIRS) or repeat PCNL was considered as auxiliary treatment alternative when indicated. The Double-J stent was left in situ for four weeks to facilitate the passage of stone fragments. Blood transfusion was administrated when hemoglobin (Hb) < 7.0 g/L during or post operation. Severe bleeding was defined as intraoperative or postoperative renal hemorrhage requiring blood transfusion or angiographic embolization. Stone free was defined as the absence of any residual stones in kidney or had clinically insignificant residual fragments (CIRFs), meaning ≤ 4 mm, non-infectious, non-obstructive and asymptomatic residual fragments. All patients were assessed by KUB or computerized tomography (CT) 1 month after the final procedure to confirm the final stone-free rate (SFR).

Follow-up

Follow-up protocol included history, blood routine test, urine analysis, serum creatinine, KUB and renal ultrasonography. CT scan was performed for assessment of patients with deteriorated renal functions or stone recurrence. Serum creatinine was measured before and 2 h after the operation, on the first postoperative day, and at each follow-up visit. The eGFR was calculated using the four-variable modification of diet in renal disease (MDRD) equation.

Statistical Analysis

Of 48 patients, 44 were followed for at least 6 months, whereas four patients were lost to follow-up; therefore, eGFR and CKD were calculated for the remaining 44 patients. Paired *t* test was used to compare the changes in the preoperative and postoperative serum creatinine and eGFR values. Increase in the eGFR over 20% was considered as improvement, decrease over 20% as deterioration, and changes within 20% as stationary in renal function [8]. Perioperative clinical factors that may affect renal function were tested using univariate (Student's *t* test or Fisher's exact test) analyses to define factors predicting renal function improvement on long-term follow-up.

Results

The study included 48 patients [33 men (68.8%) and 15 women (31.2%)]. Patients' mean age was 51.4 ± 12.0 years (range 24–74 years). The mean operative time was 75.1 ± 23.8 min (range 30–130 min). The mean length of postoperative hospitalization was 4.63 ± 0.97 days (range 3–7 days). In the 44 patients who completed the study, 24 patients (56.8%) were stone free after single session PCNL. For auxiliary treatments, 14 patients (31.8%) had residual stones for second stage PCNLs, RIRS retrieval was performed for five patients, and SWL was performed for three patients. After all the procedures, nine more patients became stone free, and three had insignificant fragments < 4 mm. So, the final stone-free rate was 81.8%. After a median follow-up of 12 months (range 6–26), spontaneous stone passage was noticed in one patient with CIRFs, two showed growth of the residuals, six showed the same post-PNL residuals, whereas one patient had recurrence of the stones. Those patients with recurrence or regrowth of the residuals were managed with RIRS or PCNL. Average eGFR values were 53.9 ± 24.0 mL/min/1.73 m^2 during the preoperative period, 49.6 ± 21.0 mL/min/1.73 m^2 2 h after operation, 50.9 ± 24.5 mL/min/1.73 m^2 post operative day 1, and 61.3 ± 25.4 mL/min/1.73 m^2 at the last follow-up visit (≥ 6 months), respectively. The late

Table 1: Univariate analysis of risk factors for deterioration of the renal function after PCNL in solitary kidney (Fisher or *t* test). Univariate analysis of factors for improvement of renal function after PCNL in solitary kidney (Fisher or *t* test).

Factors	Deteriorated or stationary eGFR	Improved eGFR	*P* value
Age in year, mean (SD)	50.4 (13.4)	50.6 (9.3)	0.967
Baseline eGFR (ml/ min/1.73 m^2), mean (SD)	55.5 (23.8) N (%)	49.7 (24.9) N (%)	0.476
Gender			1.000
Male	23 (71.9)	9 (28.1)	
Female	9 (75.0)	3 (25.0)	
Metabolic syndrome			0.663
Yes	5 (62.5)	3 (27.5)	
No	27 (75.0)	9 (25.0)	
Hyperuricemia			0.315
Yes	18 (66.7)	9 (33.3)	
No	14 (82.4)	3 (17.6)	
Open surgery history			1.000
Yes	8 (72.7)	3 (27.3)	
No	24 (72.7)	9 (27.3)	
eGFR category			0.322
> 30 mL/min	29 (76.3)	9 (23.7)	
15–30 mL/min	3 (50)	3 (50)	
Urine culture			0.733
Positive	14 (77.8)	4 (22.2)	
Negative	18 (69.2)	8 (30.8)	
Nature of solitary kidney			0.507
Non-functional	15 (78.9)	4 (21.1)	
Functional	17 (68.0)	8 (32.0)	
Stone burden			0.259
Simple	7 (58.3)	5 (41.7)	
Complex	25 (78.1)	7 (21.9)	
Number of tracts			0.068
Single	19 (63.3)	11 (36.7)	
Multiple	13 (92.9)	1 (7.1)	
Hydronephrosis			0.658
None or mild	28 (73.7)	10 (26.3)	
Moderate or severe	4 (66.6)	2 (33.4)	
PCNL			0.068
One stage	19 (63.3)	11 (36.7)	
Staged	13 (92.9)	1 (7.1)	

(continued)...

...(continued)

Factors	Deteriorated or stationary eGFR	Improved eGFR	*P* value
Tract dilation			0.722
Balloon	10 (66.7)	5 (33.3)	
Serial	22 (75.9)	7 (24.1)	
Severe Bleeding			0.551
Yes	3 (100)	0 (0)	
No	29 (70.7)	12 (29.3)	
Post-PCNL residuals			0.733
Stone free	18 (69.2)	8 (30.8)	
Residual stones	14 (77.8)	4 (22.2)	
Stone composition			1.000
Struvite	3 (50)	3 (50)	
Non-struvite	29 (76.3)	9 (23.7)	
Auxiliary procedure			0.173
Yes	17 (85.0)	3 (15.0)	
No	15 (62.5)	9 (37.5)	
Preoperative anemia			1.000
Yes	3 (42.9)	4 (57.1)	
No	29 (78.4)	8 (21.6)	

Table 2: Literature review of guidance method, outcomes, complications, and postoperative renal function changes of patients with solitary kidneys underwent PCNL.

References	Patient number	Guidance	Initial stone-free rate (%)	Final stone-free rate (%)	Compli-cation (%)	Trans-fusion (%)	Renal function change
Liou *et al*. [22]	30	X-ray	NR	NR	NR	NR	Stable
Canes *et al*. [13]	81	X-ray	NR	NR	8.6	4.3	Improved
Resorlu *et al*. [23]	16	X-ray	81.3	93.7	62.5	18.8	Improved
Akman *et al*. [14]	47	X-ray	84.5	90.9	10.6	6.4	Improved
Basiri *et al*. [24]	30	X-ray	NR	95.3	23.3	3.3	Stable
Bucuras *et al*. [25]	189	X-ray and/ or US	65.4	NR	29.6	10.1	Improved
Wong *et al*. [26]	17	X-ray	58.8	76.5	35.3	5.9	Improved
El-Tabey *et al*. [8]	200	X-ray	81.5	89.5	17	5.0	Improved
Torricelli *et al*. [27]	27	X-ray	NR	67	29.6	18.5	Improved
Hosseini *et al*. [28]	412	X-ray	81	91.3	19.2	4.6	NR
Bai *et al*. [29]	60	X-ray	35.7	88.3	31.7	11.7	NR

US ultrasound, *NR* not reported

postoperative eGFR was significantly improved when compared with the preoperative eGFR ($P < 0.01$). Twelve patients (27.3%) showed improvement in eGFR, 29 (65.9%) showed stationary eGFR, whereas three (6.8%) showed deterioration. No patient developed end stage renal disease or maintained on hemodialysis.

In the 33 patients (68.7%) with complex stones, staghorn calculi were found in 18 (37.5%) patients. Stone analysis showed 40 (83.3%) calcium based stones, 2 (4.2%) uric acid stones, 6 (12.5%) struvite (magnesium ammonium phosphate).

Complications were reported in 8 patients (16.7%). Five patients (10.4%) had fever (temperature of 38.5 °C or greater). Blood transfusions were required in three (6.3%) patients. All of them were successfully treated conservatively; no angioembolization was required. No urosepsis was detected. Neither hydrothorax nor hemothorax developed in any patient. Factors that may associated with renal function changes were listed and analysed in Table 1.

Discussion

PCNL is recommended as the gold standard intervention for patients with large and complex renal calculi [9]. This procedure has the advantages of a higher stone-free rate and acceptable complications when compared with other treatment alternatives such as RIRS and open surgery [2]. For challenging cases such as patients with solitary kidneys, PCNL is also an appropriate treatment choice [4].

Previous reported PCNLs in solitary kidneys were mostly performed under fluoroscopic guidance [4]. Ultrasound-guided renal access for PCNL has becoming more widely used, and was found to have shorter puncture time, higher success rate of first puncture, and less blood loss, as compared with fluoroscopic guidance in patients with normal bilateral kidneys [10]. However, it is seldom reported in patients with solitary kidneys. In present study, all percutaneous renal accesses were achieved under total ultrasound guidance. Our final stone-free rate of 81.8% and total complication rate of 16.7% were comparable to those of fluoroscopy-guided PCNL in solitary kidneys (Table 2). Moreover, staghorn calculi were found in 37.5% of patients in our study. These results fully demonstrated that ultrasound guided PCNL is a safe and effective treatment approach for stones in solitary kidneys.

The primary concern of PCNL in solitary kidneys is the risk of uncontrollable hemorrhage that may necessitate embolization or even a nephrectomy [2]. Transfusion rate for severe bleeding generally varies between 3.3 and 18.8% according to previously reported PCNL series in solitary kidneys (Table 2). Most bleeding can be managed with conservative treatment, with less than 1.5% of the patients requiring angioembolization [11]. Reported risk factors for severe bleeding included multiple accesses, solitary kidney and an inexperienced surgeon [12]. In the present study, hemorrhage that required a blood transfusion was observed in three (6.3%) patients. The transfusion rate was comparable to prior fluoroscopy-guided series. All the three patients who needed blood transfusion had the staghorn calculi and required multiple accesses during the PCNL procedure. However, all of them were successfully treated conservatively, and no angioembolization was required.

The second concern when performing PCNL in solitary kidneys was the possible effect of PCNL on renal function at both short- and long-term follow-ups. In the present study, the mean preoperative eGFR was 53.9 ± 24.0 mL/min/1.73 m^2 and calculated at 50.9 ± 24.5 and 61.3 ± 25.4 mL/min/1.73 m^2 during the early and late postoperative periods, respectively. A significant improvement in mean eGFR was detected at the last follow-up when compared with the preoperative level ($P < 0.01$). Thus, the postoperative function of solitary kidneys after long-term follow-up was significantly improved in our study. This result was in accordance with other fluoroscopic-guided series (Table 2). The possible reasons for such improvement could be clearance of infection and relief of obstruction by stone removal [13]. However, a temporary decrease in mean eGFR during the early postoperative period was also detected, which may be due to acute injury or hydrodistention of the kidney during the surgery [14].

Without the compensation of contralateral normal kidney, patients with solitary kidneys provided a unique opportunity to investigate the factors affecting renal function in the late post-PCNL period. Struvite pertains to the infectious stones, which were associated with infection of urease-producing bacteria, such as *proteus mirabilis* [15]. Patients with struvite are deemed at high risk of recurrence, and often suffer from repeated urinary infection, which deteriorated the renal function [16]. Mayo *et al.* [17] found significant improvement in the function of renal units containing infectious stones underwent PCNL through radionuclide studies. However, in our study, we detected no statistically significant correlation between stone composition and postoperative kidney function.

Tract dilatation is a major procedure in PCNL, which can be done using serial or balloon dilators. Balloon dilation has been observed with higher bleeding and transfusion rates as well as a total longer operative time compared with serial dilation [18]. However, their influence on renal function has never been reported due to the influence of normal contralateral kidney. In our series of patients with solitary kidneys, balloon dilation was used in 34.1% of the patients;the rest of them were dilated with serial dilation. We detected no significant correlation between dilation method and postoperative kidney function. This result indicated that the dilation method has little effect on renal function improvement after PCNL.

The metabolic syndrome (MS) is a cluster of cardiovascular disease risk factors that includes dyslipidemia, hypertension, central obesity, hyperglycemia, and diabetes mellitus [6]. This disease is also associated with an increased risk for chronic kidney disease and urolithiasis [19]. Akman *et al.* [19] reported that MS was associated with worsening renal function in patients underwent PCNL after a minimum follow-up of 12 months, and the mean eGFR was decreased significantly at last follow-up in the MS group. However, the normal contralateral kidney may be a confounding factor in this study. In two studies about PCNL in solitary kidney, underwent PCNL, patient-related factors including BMI, hypertension and diabetes mellitus, which were components of MS, have been reported to have no significant correlation with postoperative kidney function [8, 14]. In the present study, eight patients were diagnosed with MS. The eGFR at last follow-up were deteriorated in one patient, improved in three patients, and stationary in others. We detected no statistically significant correlation between MS and postoperative kidney function. In addition, we also found no significant correlation between postoperative kidney function and hyperuricemia, which is closely associated with MS and has been considered as an independent risk factor for renal impairment in patients who had renal cell carcinoma and underwent unilateral nephrectomy [20, 21].Therefore, the correlation between MS, hyperuricemia and post-PCNL renal function needs further investigation depending on a large-scale prospective study.

We recognize three limitations in our study. First, it is limited by its retrospective nature as well as relatively short follow-up duration and small patient numbers. Future large-scale and long-term prospective studies are needed. Secondly, the influence of some variables such as mean stone volume, operative time, history of PCNL, and estimated blood loss were not included in our study. Thirdly, we can not analyze risk factors for renal function deterioration after PCNL, which is important in differentiating high-risk patients before operation. Further studies can be done from this perspective.

Conclusions

Ultrasound-guided PCNL is a safe and feasible procedure, compared to fluoroscopy-guided PCNL, with acceptably low complication rate in patients with solitary kidneys. The renal function in more than 90% of the patients with solitary kidneys can be improved or stabilized after PCNL at long-term follow-up.

References

1. Kallidonis P, Panagopoulos V, Kyriazis I *et al.* (2016) Complications of percutaneous nephrolithotomy: classification, management, and prevention. Curr Opin Urol 26:88.
2. Seitz C, Desai M, Hacker A *et al.* (2012) Incidence, prevention, and management of complications following percutaneous nephrolitholapaxy. Eur Urol 61:146.
3. Gambaro G, Favaro S, D’Angelo A (2001) Risk for renal failure in nephrolithiasis. Am J Kidney Dis 37:233.
4. Jones P, Aboumarzouk OM, Rai BP *et al.* (2017) Percutaneous nephrolithotomy for stones in solitary kidney: evidence from a systematic review. Urology 103:12.
5. Falahatkar S, Allahkhah A, Kazemzadeh M *et al.* (2016) Complete supine PCNL: ultrasound vs. fluoroscopic guided: a randomized clinical trial. Int Braz J Urol 42:710.
6. Kocher NJ, Rjepaj C, Robyak H *et al.* (2017) Hypertension is the primary component of metabolic syndrome associated with pathologic features of kidney cancer. World J Urol 35:67.
7. Li J, Xiao B, Hu W *et al.* (2014) Complication and safety of ultrasound guided percutaneous nephrolithotomy in 8025 cases in China. Chin Med J (Engl) 127:4184.
8. El-Tabey NA, El-Nahas AR, Eraky I *et al.* (2014) Long-term functional outcome of percutaneous nephrolithotomy in solitary kidney. Urology 83:1011.
9. Bultitude M, Smith D, Thomas K (2016) Contemporary management of stone disease: the new EAU urolithiasis guidelines for 2015. Eur Urol 69:483.
10. Wang K, Zhang P, Xu X *et al.* (2015) Ultrasonographic versus fluoroscopic access for percutaneous nephrolithotomy: a metaanalysis. Urol Int 95:15.
11. El-Nahas AR, Shokeir AA, El-Assmy AM *et al.* (2007) Post-percutaneous nephrolithotomy extensive hemorrhage: a study of risk factors. J Urol 177:576.
12. Srivastava A, Singh KJ, Suri A *et al.* (2005) Vascular complications after percutaneous nephrolithotomy: are there any predictive factors? Urology 66:38.
13. Canes D, Hegarty NJ, Kamoi K *et al.* (2009) Functional outcomes following percutaneous surgery in the solitary kidney. J Urol 181:154.

14. Akman T, Binbay M, Tekinarslan E *et al.* (2011) Outcomes of percutaneous nephrolithotomy in patients with solitary kidneys: a single-center experience. Urology 78:272.
15. Skolarikos A, Straub M, Knoll T *et al.* (2015) Metabolic evaluation and recurrence prevention for urinary stone patients: EAU guidelines. Eur Urol 67:750.
16. Carpentier X, Daudon M, Traxer O *et al.* (2009) Relationships between carbonation rate of carbapatite and morphologic characteristics of calcium phosphate stones and etiology. Urology 73:968.
17. Mayo ME, Krieger JN, Rudd TG (1985) Effect of percutaneous nephrostolithotomy on renal function. J Urol 133:167.
18. Lopes T, Sangam K, Alken P *et al.* (2011) The clinical research office of the endourological society percutaneous nephrolithotomy global study: tract dilation comparisons in 5537 patients. J Endourol 25:755.
19. Akman T, Binbay M, Erbin A *et al.* (2012) The impact of metabolic syndrome on long-term outcomes of percutaneous nephrolithotomy (PCNL). BJU Int 110:E1079.
20. Jeon HG, Choo SH, Jeong BC *et al.* (2013) Uric acid levels correlate with baseline renal function and high levels are a potent risk factor for postoperative chronic kidney disease in patients with renal cell carcinoma. J Urol 189:1249.
21. Tanaka Y, Hatakeyama S, Tanaka T *et al.* (2017) The influence of serum uric acid on renal function in patients with calcium or uric acid stone: a population-based analysis. PLoS One 12:e182136.
22. Liou LS, Streem SB (2001) Long-term renal functional effects of shock wave lithotripsy, percutaneous nephrolithotomy and combination therapy: a comparative study of patients with solitary kidney. J Urol 166(36):36.
23. Resorlu B, Kara C, Oguz U *et al.* (2011) Percutaneous nephrolithotomy for complex caliceal and staghorn stones in patients with solitary kidney. Urol Res 39:171.
24. Basiri A, Shabaninia S, Mir A *et al.* (2012) The safety and efficacy of percutaneous nephrolithotomy for management of large renal stones in singleversus double-functioning kidney patients. J Endourol 26:235.
25. Bucuras V, Gopalakrishnam G, Wolf JJ *et al.* (2012) The clinical research office of the endourological society percutaneous nephrolithotomy global study: nephrolithotomy in 189 patients with solitary kidneys. J Endourol 26:336.
26. Wong KA, Sahai A, Patel A *et al.* (2013) Is percutaneous nephrolithotomy in solitary kidneys safe? Urology 82:1013.
27. Torricelli FC, Padovani GP, Marchini GS *et al.* (2015) Percutaneous nephrolithotomy in patients with solitary kidney: a critical outcome analysis. Int Braz J Urol 41:496.
28. Hosseini MM, Yousefi A, Hassanpour A *et al.* (2015) Percutaneous nephrolithotomy in solitary kidneys: experience with 412 cases from Southern Iran. Urolithiasis 43:233.
29. Bai Y, Wang X, Yang Y *et al.* (2017) Percutaneous nephrolithotomy versus retrograde intrarenal surgery for the treatment of kidney stones up to 2 cm in patients with solitary kidney: a single centre experience. BMC Urol 17:9.

Affiliations

Boxing Su[1], Wenyi Liang[2], Weiguo Hu[1], Bo Xiao[1], Xin Zhang[1], Song Chen[1], Yuzhe Tang[1], Yubao Liu[1], Meng Fu[1], Wenjie Bai[1], Jianxing Li[1]

Boxing Su
05202154@163.com

Wenyi Liang
19880203lwy@163.com

Weiguo Hu
weiguohu2006@126.com

Bo Xiao
beidaxiaobo@163.com

Xin Zhang
zhangxin19731@hotmail.com

Song Chen
chen1968song@sina.com
Yuzhe Tang
hip-hopzone@163.com

Yubao Liu
justin77337733@sina.com

Meng Fu
fumeng0830@163.com

Wenjie Bai
18301209698@163.com

[1]Department of Urology, School of Clinical Medicine, Beijing Tsinghua Changgung Hospital, Tsinghua University, No. 168 Litang Road, Changping District, Beijing 102218, China
[2]Department of Geriatric Medicine, Peking University First Hospital, Beijing, China

Source: Su, B., Liang, W., Hu, W. *et al*. *World J Urol* (2019) 37: 951. https://doi.org/10.1007/s00345-018-2458-5.

To Dust or Not To Dust: A Systematic Review of Ureteroscopic Laser Lithotripsy Techniques

Javier E. Santiago[1], Adam B. Hollander[2], Samit D. Soni[2], Richard E. Link[2], Wesley A. Mayer[2]

Abstract

Purpose of Review: This review discusses factors affecting outcomes during ureteroscopy (URS) with laser lithotripsy (LL), explores specific clinical challenges to the efficacy of URS LL, and reviews the available literature comparing the dusting and basketing approaches to URS LL.
Recent Findings: Data show high stone-free rates with URS LL in all locations of the urinary tract and with all stone types and sizes. Recent data comparing LL with dusting versus basketing suggest higher rates of residual fragments with dusting but less utilization of ureteral access sheaths and potentially shorter operative times. Differences in postoperative complications, re-intervention rates, and other outcome parameters are not yet clear. Interpretation of published data is problematic due to variability in laser settings, follow-up intervals, and definitions for what constitutes stone-free status.
Summary: URS has overtaken shock wave lithotripsy in the last decade as the most commonly utilized surgical approach for treating urolithiasis. Two primary strategies have emerged as the most common techniques for performing LL: dusting and basketing. There is a relative paucity of data examining the difference in these techniques as it pertains to perioperative outcomes and overall success. We attempt to synthesize this data into evidence-based and experience-based recommendations.

Electronic supplementary material The online version of this chapter (doi:10.1007/s11934-017-0677-8) contains supplementary material, which is available to authorized users.

Wesley A. Mayer
e-mail: wamayer@bcm.edu
[1]Baylor College of Medicine, Houston, TX, USA
[2]Scott Department of Urology, Baylor College of Medicine, 7200 Cambridge, 10th Floor, Urology Suite B, Houston, TX 77030, USA

This article is part of the Topical Collection on Endourology

Keywords: Urolithiasis, Dusting, Basketing, Ureteroscopy, Residual fragments, Laser lithotripsy

Introduction

For the past three decades, technological innovation has driven evolution in surgical management of urolithiasis. Flexible fiber-optic ureteroscopes, first introduced in the 1980s, simplified access into the ureter and kidney and allowed visualization of regions that were unreachable with the preexisting rigid and semi-rigid instruments [1]. Dual deflection mechanisms improved access to the lower and upper poles of the kidney. These ureteroscopes, however, were still relatively large with sizes up to 11.5 Fr and associated with a risk for significant complications, as high as 6.6% [2].

Extracorporeal shock-wave lithotripsy (SWL), developed in the early 1980s, was an attractive and less invasive alternative to ureteroscopy (URS) that ultimately became the mainstay of treatment for uncomplicated urolithiasis. However, harder stones (calcium oxalate monohydrate and cysteine) fragment poorly with SWL [3]. Since SWL only generates an equivalent volume of stone fragments, the patient must spontaneously pass all fragments to achieve stone-free status. This is particularly problematic for lower pole stones when the infundibulopelvic angle is acute, since gravity tends to trap fragments inferiorly. To facilitate passage of lower pole fragments after SWL, urologists developed a variety of complicated positional drainage maneuvers (i.e., total body inversion) [4–6]. Moreover, stone-free rates (SFR) with SWL for larger stones are low and multiple procedures are often required [7–10]. Consequently, the AUA guidelines recommend limiting SWL to stones <1.5 cm that are not located in the lower pole [11].

During the 1990s, miniaturization and improved mechanics fueled development of smaller flexible ureteroscopes with large working channels. These new instruments delivered effectors (i.e., baskets and lasers) to less accessible areas of the kidney, greatly improving the versatility of URS. Clearer visualization with digital ureteroscopes as compared to the original fiber-optic system shortened procedure times and improved safety [12, 13]. The result has been a nearly 20% drop in SWL usage among urologists in favor of URS, which has overtaken SWL in the last decade as the most commonly utilized surgical approach for urolithiasis [14]. Data demonstrating high SFR with URS for stones in all urinary tract locations have led to guideline statements encouraging URS for an expanding group of patients with various stone compositions and locations [11, 15].

Cost is a significant concern for flexible ureteroscopes, particularly due to the frequency of scope damage requiring costly repair [16–18]. Beyond good surgical technique, the use of less traumatic ball-tipped laser fibers may extend instrument life and lower the frequency of repairs [19]. High quality, low-cost disposable ureteroscopes may also decrease the cost of ownership and improve general access to flexible URS [20, 21].

Intracorporeal lithotripsy can be accomplished by applying ultrasonic, mechanical, electrohydraulic, or laser energy to the stone under direct vision. Laser lithotripsy (LL) has become the recommended ureteroscopic energy source by the American Urologic Association (AUA) and the European Urologic Association (EUA) due to its compatibility with rigid, semi-rigid, and flexible ureteroscopes, relative safety with regards to adjacent tissue injury, lower risk of stone migration, and efficacy for fragmenting all types of stones.

"Basketing" and "dusting" have emerged as two alternative strategies for LL [22]. Basketing involves laser fragmentation of stones into smaller fragments using high-power, low frequency laser pulses followed by active removal with retrieval devices, often through a ureteral access sheath (UAS). Dusting utilizes low-power, high-frequency laser pulses to melt stones into tiny, dust-like fragments that can be passed spontaneously. In this review, we will outline the important factors differentiating each technique, summarize the available data comparing them, and provide recommendations concerning the ideal clinical scenarios for each.

Physics of Laser Lithotripsy

A basic understanding of laser physics is a prerequisite to any discussion of basketing and dusting. Lasers optically or electrically excite a semi-conductive material and then oscillate photons released by uniform population inversion between two mirrors [23]. One of these mirrors is slightly less reflective, resulting in the release of a beam of photons of a specific wavelength from that end. The pulse energy is absorbed by the stone and generates an oscillating cavitation bubble, creating mechanical shockwaves that destabilize and fragment most types of stones [23].

The most commonly used laser type for LL is the holmium/ YAG laser (Ho/YAG), a solid-state laser producing a 350 ms pulse with a wavelength of 2150 nm to deliver 200–4000 mJ. Small diameter fibers (≤200 μm) are widely available for this laser, allowing energy to be applied through ureteroscopes with small working channels. This maximizes scope deflection, flexibility, and irrigant flow for better maneuverability and visibility. The Ho/YAG destabilizes stones via a photothermal effect, as the energy is absorbed by water near the stone, creating a vaporization bubble around the tip of the laser that achieves stone destabilization and fragmentation. The Ho/YAG fiber tip should be kept 1 mm from ureteral and renal tissue with adequate irrigation to minimize risk of damage secondary to heat production or direct cutting action. Higher powered Ho/YAG lasers (120 W) provide greater flexibility in adjusting pulse parameters to customize the effect to an individual stone composition or technique of LL.

When purchasing a Ho/YAG laser generator for ureteroscopic LL (URS LL), recognize that total power is not necessarily the most critical feature. The versatility of a laser in treating stones is a function of three factors: total power, pulse frequency, and pulse width. Lower powered lasers (i.e., most 30 W units) are smaller, less costly, and more convenient to operate with standard 110 V power. Yet, they cannot usually support the high pulse frequencies (up to 80 Hz) used for stone dusting. Lasers of 100 and 120 W are more costly and often require 220 V power outlets, creating logistical problems in the operating room. However, the ability to use high-frequency pulses with these lasers, along with their utility for prostate surgery, may make the investment worthwhile. Another factor is the ability to control pulse width, a feature limited to a subset of 100–120 W units. Pulse width adjustment can minimize "retropulsion" which refers to backward bouncing movement of a stone in response to LL. Less retropulsion may make URS LL more convenient and efficient in the ureter, resulting in less "chasing" of the stone proximally.

Challenges to the Interpretation of the Literature

Investigators focus on SFR when comparing different forms of lithotripsy. However, SFR criteria are not standardized across studies and can differ greatly depending on the length of follow-up and the imaging modality. Non-contrast CT (NCCT) is most sensitive for stone detection and is particularly superior to other modalities such as ultrasound and plain abdominal films (KUB) for detecting stones <4 mm [24]. Ultrasound, in experienced hands, provides accurate information about renal stone burden but is poor for visualizing ureteral calculi, particularly in obese patients. The operator dependent nature of ultrasound can lead to inconsistencies in determining SFR after lithotripsy. While inexpensive and convenient, KUB cannot detect radiolucent stones and may miss residual stones obscured by overlying abdominal contents, bowel gas, or stool.

SFR does not always reflect complete clearance of all stone fragments. Published studies use varying definitions of stone-free that include residual stones ranging from 1 to 4 mm. Variability in patient factors such as anatomy, stone location, stone composition, total stone burden, compliance (either with post-procedure medication and/or imaging follow-up), equipment, and surgeon skill/persistence can complicate comparisons across studies.

Factors Affecting Stone-Free Rate in Ureteroscopic Laser Lithotripsy

URS LL results in an excellent SFR for stones at all levels of the upper urinary tract [25–27]. However, two categories of patients warrant closer examination: those with stones >2 cm and those with lower pole calyceal stones [28].

For stones >2 cm, percutaneous nephrolithotomy (PCNL) is considered first-line therapy due to superior SFR [11, 29]. URS LL can be considered when patients are poor candidates for PCNL due to medical comorbidities, anatomic challenges to percutaneous access, or an inability to stop anticoagulation. Staged URS for large stones may be an option but can require several lengthy procedures. Multiple long ureteroscopic procedures may also carry an increased risk of infectious complications [30]. A 2010 meta-analysis of URS LL management of stones >2 cm found a 95% SFR after a mean of 1.46 procedures, but SFR definitions were not standardized across studies, and the follow-up interval was ≤3 months [31]. More recently, Al-Qahtani *et al*. and Cohen *et al*. reported SFR of 97 and 87% at 1 and 3 months, respectively, with mean 1.6 procedures [32, 33]. Hyams *et al*. investigated single-stage URS procedures and found SFR of 63% (no fragments >2 mm) or 47% (fragment-free) at 2-month follow-up [34].

Ureteroscopic access to lower pole stones poses challenges due to the greater deflection required. Instruments in the working channel can decrease deflection as much as 10–45° and limit clearance of residual fragments [35]. Retained fragments in the lower pole calyx may be less likely to pass into the renal pelvis due to gravity, especially in patients with an acute infundibulopelvic angle [36, 37]. Despite these factors, URS LL has achieved high SFR in the treatment of lower pole stones with lower retreatment rates compared to SWL (8 vs 60–85%) [38–40]. URS also allows repositioning of stones into upper pole calyces which can facilitate spontaneous passage of residual fragments created by LL.

Basketing

Basketing involves using URS LL to break stones into 2–4mm fragments that can be actively removed using a retrieval device (usually a coaxial basket or grasper) rather than left in situ for spontaneous passage. This theoretically allows for complete stone removal under direct visualization. Retrieval also provides stone samples for chemical analysis, helping guide lifestyle recommendations and medical management to attenuate the ~52% 10-year risk of stone recurrence in first-time formers [41–44].

The authors utilize higher power (0.8 to 1.2 J) and lower frequency (8–12 Hz) laser settings for basketing. These settings can fracture stones into larger fragments but also create significant stone movement and retropulsion [45]. Also, the high power of each individual pulse can potentially damage the laser fiber and contributes to "burn back," the process by which the tip of the fiber becomes ablated during lithotripsy [46].

Unfortunately, there is a relative paucity of data comparing URS LL with basketing settings and active retrieval to in situ passage of residual fragments. In the only randomized controlled trial comparing the two strategies, Shatloff *et al*. treated 60 patients with ureteral stones by either active retrieval or more vigorous fragmentation to <2 mm followed by spontaneous passage. Stones were of mean size 9 and 10 mm, respectively. The number of ER visits was significantly higher (30 vs 3%, $p < 0.01$) at 1 month post-operation for the spontaneous passage treatment arm. Operative time was equivalent between the two arms at a mean of 26 min. Other measures including SFR (100% in the retrieval arm, 87% in the spontaneous passage arm) were not significantly different [47]. In a prospective study investigating active stone retrieval, Portis *et al.* treated kidney and proximal ureteral stones of mean size 9.4 mm with the basketing strategy. With residual stones defined as <2 and <4 mm, they reported an SFR of 85 and 97%, respectively, at 1 month with NCCT [48]. Using a more stringent definition of SFR as measured by NCCT 1–3 months postoperatively, two retrospective studies documented SFR of 55–60% for basketing vs 35% when URS was performed with basketing laser settings but without active fragment retrieval [28, 49]. The outcome is less clear for studies examining residual stones <2 and <3 mm [50, 51].

Use of a UAS can facilitate multiple passes to accomplish complete stone removal. Available in various diameters and lengths to suit particular patients and procedures, UASs provide a protective barrier between instrumentation and the ureteral wall. They may also keep intrarenal pressures lower during URS, decreasing the risk of post-procedure systemic inflammatory response or sepsis [52–54]. This dilation and barrier function facilitate removal of sizable stone fragments and efficient re-entry of the ureteroscope while minimizing ureteral trauma outside of the initial placement of the device. UASs also decrease operative time and double durability of ureteroscopes by protecting the tip and preventing kinking within the ureter [55, 56]. In cases with larger stone burdens, the use of UASs virtually eliminates the risk of scope entrapment by distally migrated stone fragments caught between the ureteroscope and ureteral wall.

Two studies have compared SFR in URS LL with and without UAS usage. In a retrospective analysis for stones of mean size 1–2 cm, Berquet *et al*. found that placing a UAS was not associated with a significant difference in SFR at any anatomic location when residual fragments were defined as <3 mm assessed by CT or US at 1 and 3 months [57]. In a comparable study of UAS usage for stones ranging from 5 to 10 mm, L'Esperance *et al.* found a statistically significant overall improvement in renal stone SFR with UAS usage at 2 months by IV urography ($p = 0.04$) [58]. Given limited comparative investigations, a definitive statement on SFR outcomes with UAS usage is not possible.

Potential intraoperative and postoperative complications specific to UAS use exist. Ureteral injury can result from shearing injury during UAS insertion into a narrow ureter or from ureteral wall ischemia [59]. A 2013 prospective study reported that 46.5% of 359 patients had visible ureter damage graded on a 4 point scale after 12 or 14 Fr UAS placement [60•]. This included 86% with mucosal injury, 10% with damage through the mucosa to the smooth muscle, and 3.3% with full-thickness ureteral injury. The factor with the greatest association ureteral injury with UAS use was the absence of preoperative double-J stent placement. Thus, pre-stenting remains a valid consideration in cases of difficult UAS placement or known damage and before URS in patients with prior complications [11]. The impact of the observed damage on future stricture development is unknown due to insufficient follow-up, although one study reported no increased risk when compared to no UAS usage [61]. Also, a 2015 prospective global collaboration study on 2239 patients comparing outcomes with and without UAS found no significant difference in intra-operative bleeding or ureteral perforation, nor in postoperative bleeding or infection [62]. However, a retrospective study including 298 URS LL patients found an association between increasing UAS diameter and younger age with unplanned symptomatic encounters [63]. These data may be representative of more recent widespread use of UASs and should serve as a reminder to approach UAS usage and sizing thoughtfully with awareness of the potential for injury.

Additional potential downsides to the basketing technique include the added cost of retrieval devices, increased technical challenge to manually remove stones, potentially longer operative times, and surgeon frustration due to the tedium of sequentially basketing many fragments. None of these factors have been studied.

Dusting

Dusting is a URS LL technique employing lower energy laser pulses (the authors recommend 0.2–0.4 J) at a much higher pulse rate (40–80 Hz), with the goal of reducing a stone to fine dust that can be spontaneously passed in a pain-free manner. These settings require a more powerful laser (100–120 W), which may not be available at all institutions. The difference between basketing and dusting lies primarily in the size of the residual fragments generated. With dusting, the stone is "painted" with the laser energy and dissolved into fine dust. Ideally, the dusting approach results in no residual fragments of a size that might require basket extraction. Larger fragments inadvertently created during dusting can be treated with similar settings by using a "popcorn technique." This involves treating multiple small fragments with constant laser energy at a very high frequency directed in one area, causing the fragments to "bounce" around and contact the laser energy by chance, eventually reducing them to dust. Given the available data showing reduced

SFR for lower pole stones following SWL, relocating lower pole calculi to another calyx using a basket prior to dusting could potentially improve clearance of dusting fragments [64].

Dusting has several potential advantages over basketing. It eliminates the need for multiple passes of the ureteroscope in and out of the ureter to remove multiple fragments and may lessen the need for UAS placement. Dusting may decrease the tedium of extracting a large number of stone fragments, possibly reducing operative time [65, 66]. However, stone composition may affect the efficiency of dusting. Laser settings for dusting seem to be most effective for stones under 1100 HU (i.e., calcium oxalate dihydrate, calcium phosphate, and uric acid). Dusting may be less effective for denser stones with higher HU, such as calcium oxalate monohydrate, which tend to fragment into large pieces that may require basket retrieval. Ghani compared dusting efficiency with a 60–100-W holmium laser vs a 120-W holmium laser [67]. The more powerful laser generator enables higher-frequency settings up to 80 Hz and provides greater control over pulse width. Such versatility in laser parameters may allow for better fragmentation of various stone types and locations. This retrospective study included 63 patients with stones of mean size 11.1 and 12.2 mm for the 60–100 and 120-W groups, respectively. Settings of 0.2–0.5 J and 30–50 Hz were used with the lower powered lasers, and settings of 0.2–0.5 J and 30–80 Hz were utilized for the higher powered lasers. Popcorn settings of 0.5 J and 80 Hz were also utilized in the 120 W arm. The 120-W group had a statistically significant higher SFR as defined by zero fragments (66% in 120 W vs 39%, $p < 0.05$). However, when SFR was defined using a 2-mm threshold, the advantage for 120 W lost statistical significance. UAS usage was similar for both groups.

Dusting Versus Basketing

While there is limited published outcome data evaluating the practice of dusting, several abstracts have been presented at national and international meetings. The largest study to date is a multi-institutional, prospective trial by the Endourologic Disease Group for Excellence (EDGE) consortium. Final data has recently been made available but without statistical analysis [68••]. Across 8 centers, 152 patients with radio-opaque kidney stones 5–20 mm in size were treated with dusting ($n = 70$) or basketing ($n = 82$). Stone size was larger in the dusting group (122.6 ± 88.6 vs 82.3 ± 59 mm^2), and densities for the dusting and basketing arms were 786 ± 362.8 and 978 ± 1150.9 HU, respectively. Three institutions involved utilized dusting and the remaining five institutions utilized basketing. Data collected included complete SFR by KUB and US within 3 months, operative time, UAS usage, and laser power. All patients were stented postoperatively and given 1 month of alpha-adrenergic blockers. SFR was higher in the basketing arm at 86.3 vs 59.2% in the dusting arm. There were no differences in stone type, rates of readmission, secondary procedures, symptoms, complications, or postoperative creatinine. In the dusting arm, 21.7% of patients had residual stones <2 mm, 10.9% 2–4 mm, and 12.5% >4 mm. Almost two-thirds had passed the residual stones between surgery and follow-up. In the basketing arm, 9.8, 7.3, and 0% had residual stones of <2, 2–4, and >4 mm, respectively. While the consortium reported early data showing a mean 19-min difference in operative time favoring dusting [65], final data results show a smaller difference in time favoring basketing, with a mean operation time of 57.8 ± 31.8 and 60.4 ± 141 min for basketing and dusting, respectively. As expected, UAS usage was much higher (100%) in the basketing group, compared to 18.2% in the dusting group. Total laser energy was higher in the dusting arm at 46.4 kJ, compared to 22.8 kJ in the basketing arm. Unfortunately, lack of statistical analysis limits definitive interpretation of this study in its current form.

Another randomized trial of dusting vs basketing by Gamal and Mamdoub examined 46 patients with <2-cm renal stones. Stone density was similar between the two groups [66]. Dusting and basketing settings were 0.2–0.4 J at 20–30 Hz and 1–2 J at 4–5 Hz, respectively. In contrast to the EDGE study, SFR was high and similar for both techniques (86% dusting vs 89% basketing). Also, dusting was associated with significantly lower operative time in this study (57 vs 70 min, $p = 0.001$). UAS usage was 0 and 100% in the dusting and basketing arms, and fewer intraoperative complications were experienced during dusting as compared to basketing. However, interpretation of this study is limited because the abstract makes no mention of a standardized follow-up period or imaging modality and does not give their definition of SFR. Importantly, the laser frequency in this study for both dusting and basketing settings is lower than typically described in the literature.

Although the lack of access to complete methods and statistical analysis limits the ability of these studies to guide management at this point, several summary points are worth making (Tables 1 and 2). There is a higher rate of residual stones with dusting in one of the studies, but without a corresponding increase in postoperative short-term complications. Concerning operative time, data from the comparative prospective studies are at odds [66, 68••]. UAS usage rates are lower and total laser energy is higher with dusting. Finally, if dusting is effective and there are no fragments to extract, stone analysis may not be obtained. These preliminary prospective studies have opened the door for comparison of the two URS LL techniques (Fig. 1). More work is needed to compare long-term outcomes such as stone recurrence and ureteral stricture formation.

Table 1: Summary of pre-published literature comparing basketing and dusting techniques for URS LL.

	No. Patients	Stone size	Zero Fragment SFR (time to f/u)	Residual stones <2mm | 2-4 mm | >4 mm	Modality	HU	Laser Settings	% UAS	Operative Time (minutes)	% Complications (Clavien)
Chew et al.[65]	Dusting: 72	5-20 mm	59.2%	21.7% 10.9% 12.5%	KUB & US	790±30	NS	18.2%	60.4±141	16.4%
	Basketing: 80		86.3% (3 months)	9.8% 7.3% 0%		978±1150		100%	57.8±31.8	13.6%
Gamal et al.[66]	Dusting: 23	<20 mm	86%	NS	NS	790±30	0.2-0.4 J 20-30 Hz	0%	57	NS
	Basketing: 23		89% (NS)			948±45	1-2 J 4-5 Hz	100%	70 (p=**0.001**)	

SFR stone-free rate, *f/u* follow-up, *NS* not specified, *HU* Hounsfield units, *UAS* ureteral access sheath usage

Table 2: Pre-published studies evaluating URS LL outcomes with 120 vs 60–100 W Holmium/YAG laser using dusting settings.

	No. Pts	Stone size	SFR by Definition (time to f/u)	Modality	HU	Laser Settings	% UAS	% Complications (Clavien)	% Staged Procedures
Ghani et al[69]			ZF | <2 mm						
	60-100 W: 28	11.1 mm	39% 57%	KUB, US, or CT	1015	0.2-0.5 J 30-50 Hz	32%	10.7%	11%
	120 W: 35	12.2 mm (p=0.41)	66% (p<0.05) 77% (p=0.11) (102 days)		948 (p=0.45)	0.2-0.5 J 30-80 Hz	37%	11.4%	32% (p=0.06)
Ghani et al[76]			ZF | <2 mm						
	120 W: 71	11.5 mm	67.2% 80.3%	KUB, US, or CT	1032.9	0.2-0.5 J 30-80 Hz	21.1%	14%	7%

SFR stone-free rate, *f/u* follow-up, *ZF* zero fragment, *HU* Hounsfield units, *UAS* ureteral access sheath

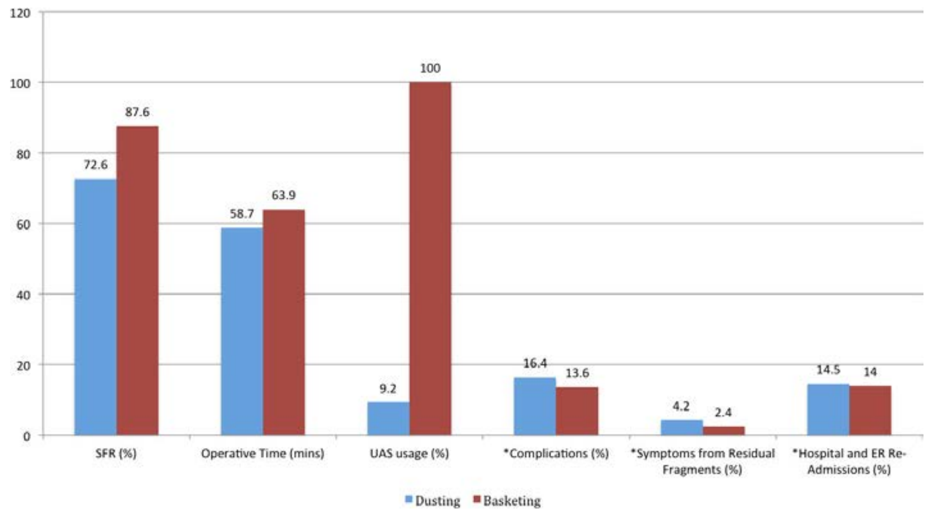


Fig. 1: Mean results from prepublished, prospective studies comparing dusting and basketing [65, 66].

Residual Fragments

Residual fragments <4 mm have been traditionally considered insignificant, with the logic being that patients can pass these stones without significant complications [69]. However, some data challenge the validity of this concept. Streem *et al.* found a 43.1% rate of symptomatic events or need for secondary intervention in patients with <4-mm residual stones after surgery [70]. Subsequent comparable investigations have found similar rates of secondary intervention (21.4–54.3%) [69, 71–73]. Across these studies, rates of stone growth were 10– 48.7% with mean follow-up periods ranging from 12 to 40.6 months [69, 72, 74].

Rebuck *et al*. retrospectively studied 46 patients with ≤4 mm residual renal stones by NCCT for a mean follow-up of 18.9 months [49]. The investigators measured stone growth, stone passage, and "stone events," defined as emergency department (ED) visits, admission, or secondary intervention for symptoms, obstruction, or removal of residual stone. Nearly 20% of patients experienced such an event, and another 21.7% of patients passed fragments symptomatically but without complication. The other 58.7% patients remained asymptomatic. Among patients with stone events requiring an additional encounter, stone growth over time was observed by NCCT: 2.5, 7.1, 5.8, and 6. 3 mm at 3, 14.4, 21.8, and 26. 8 months, respectively.

The EDGE Consortium attempted to study the natural history of residual stones both ≤4 and >4 mm [75•]. Stone events were defined as residual stone growth >1 mm by KUB or CT, stone passage, intervention, or complications (symptom recurrence, ED visit, admission, or acute kidney injury). They found a stone event rate of 44%. Re-intervention was required in 29%, and there was a complication rate of 15% at a mean follow-up of 16.7 months. Despite no significant difference between residual stones ≤4 and >4 mm in rates of spontaneous passage, residual fragments >4 mm were more likely to grow ($p < 0.001$), result in complications ($p = 0.039$), or experience re-interventions ($p = 0.01$). In further subset analysis, significantly higher rates of stone growth were seen in residual stones >2 mm when compared to ≤2 mm ($p < 0.001$), suggesting an incremental increase in morbidity with increasing residual fragment size. Preoperative stone size and lithotripsy technique (dusting vs basketing) were not associated with significant differences in outcomes. These data suggest that residual stones, even when ≤4 mm, should not be dismissed as clinically insignificant.

Conclusions

Over the past decade, indications for URS LL have greatly expanded to encompass larger stones and more diverse renal anatomy. New technologies such as high-frequency/ high-wattage lasers, purpose-built UASs, improved endoscope optics/mechanics, and more durable laser fibers have driven urologists to push the envelope with URS. Despite somewhat impassioned debate concerning the relative risks and benefits of basketing vs dusting, post-URS SFR is still primarily a function of total stone burden and stone location.

Both basketing and dusting can provide excellent surgical outcomes for patients with urolithiasis in skilled hands. In the authors' experience, a combination of dusting and basketing settings, tailored to an individual stone's composition, can often be employed to provide optimal outcomes and efficiency. Today, the available data remains too limited to make firm conclusions about which technique is most advantageous and the choice remains one of surgeon preference. However, 100–120-W lasers are rapidly becoming more widely available. This provides a future opportunity for randomized controlled trials to definitively study the relative advantages and disadvantages of both URS LL techniques.

As more research examines surgical outcomes for urolithiasis, we urge investigators in this field to standardize definitions of SFR and postoperative surveillance techniques to better compare studies. This will allow better comparisons of techniques and improve recommendations.

Compliance with Ethical Standards

Conflict of Interest Javier E. Santiago, Adam B. Hollander, and Samit Soni each declare no potential conflicts of interest. Richard E. Link reports occasional consulting for Boston Scientific.
Wesley A. Mayer reports reimbursement from Boston Scientific for a trip to the Boston Scientific Plant.

Human and Animal Rights and Informed Consent: This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
• Of importance
•• Of major importance

1. Seeger AR, Rittenberg MH, Bagley DH. Ureteropyeloscopic removal of ureteral calculi. J Urol. 1988;139(6):1180–3.
2. Harmon W, Sershon P, Blute M, *et al*. Ureteroscopy: current practice and long-term complications. J Urol. 1997;157(1):28–32.
3. Zhong P, Preminger G. Mechanisms of differing stone fragility in extracorporeal shock wave lithotripsy. J Endourol. 1994;8(4):263– 8.
4. Brownlee N, Foster M, Griffith DP, Carlton Jr CE. Controlled inversion therapy: an adjunct to the elimination of gravity-dependent fragments following extracorporeal shock wave lithotripsy. J Urol. 1990;143(6):1096–8.
5. Pace KT, Tariq N, Dyer SJ, Weir MJRJDAH. Mechanical percussion, inversion and diuresis for residual lower pole fragments after shock wave lithotripsy: a prospective, single blind, randomized controlled trial. J Urol. 2001;166(6):2065–71.
6. Chiong E, Hwee ST, Kay LM, Liang S, Kamaraj R, Esuvaranathan K. Randomized controlled study of mechanical percussion, diuresis, and inversion therapy to assist passage of lower pole renal calculi after shock wave lithotripsy. Urology. 2005;65(6):1070–4.
7. Matlaga BR, Lansen JP, Meckley LM, Byrne TW, Lingeman JE. A systematic review and meta-analysis of randomized. Contrl Trials J Urol. 2012;188(1):130–7.
8. Pearle MS, Lingeman JE, Leveillee R, Kuo R, Preminger GM, *et al*. Prospective, randomized trial comparing shock wave lithotripsy and ureteroscopy for lower pole caliceal calculi 1 cm or less. J Urol. 2005;173(6):2005–9.
9. Pearle MS, Nadler R, Bercowsky E, Chen C, *et al*. Prospective randomized trial comparing shock wave lithotripsy and ureteroscopy for management of distal ureteral calculi. J Urol. 2001;166(4):1255–60.
10. Salem HK. A prospective randomized study comparing shock wave lithotripsy and semirigid ureteroscopy for the management of proximal ureteral calculi. J Urol. 2009;74(6):1216–21.
11. Nelson CP, Pace KT, Pais VM, Pearle MS, Preminger GM. American Urological Association (AUA) guideline surgical management of stones: American Urological Association Surgical Management 2016; April:1–50.
12. Humphreys MR, Miller NL, Williams Jr JC, Evan AP, Munch LC, Lingeman JE. A new world revealed: early experience with digital ureteroscopy. J Urol. 2008;179(3):970–5.
13. Somani BK, Al-Qahtani SM, de Medina SD, Traxer O. Outcomes of flexible ureterorenoscopy and laser fragmentation for renal stones: comparison between digital and conventional ureteroscope. Urology. 2013;82(5):1017–9.
14. Oberlin DT, Flum AS, Bachrach L, Matulewicz RS, Flury SC. Contemporary surgical trends in the management of upper tract calculi. J Urol. 2015;193(3):880–4.
15. Türk C, Petřík A, Sarica K, Seitz C, Skolarikos A, Straub M, Knoll T. EUA Guidelines on Interventional Treatment for Urolithiasis. 2016;69(3)475–82.
16. Ziemba JB, Matlaga BR. Understanding the costs of flexible ureteroscopy. Minerva Urol Nefrol. 2016.
17. Tosoian JJ, Ludwig W, Sopko N, Mullins JK, Matlaga BR. The effect of repair costs on the profitability of a ureteroscopy program. J Endourol. 2015;29(4):406–9.
18. Carey RI, Martin CJ, Knego JR. Prospective evaluation of refurbished flexible ureteroscope durability seen in a large public tertiary care center with multiple surgeons. Urology. 2014;84(1): 42–5.
19. Shin RH, Lautz JM, Cabrera FJ, Shami CJ, Goldsmith ZG, Kuntz NJ, *et al*. Evaluation of novel ball-tip holmium laser fiber: impact on ureteroscope performance and fragmentation efficiency. J Endourol. 2016;30(2):189–94.
20. Doizi S, Kamphuis G, Giusti G, Andreassen KH, Knoll T, Osther PJ, *et al*. First clinical evaluation of a new single-use flexible ureteroscope (LithoVue): a European prospective multicentric feasibility study. World J Urol. 2016.

21. Leveillee RJ, Kelly EF. Impressive performance: new disposable digital ureteroscope allows for extreme lower pole access and use of 365 mum holmium laser fiber. J Endourol Case Rep. 2016;2(1): 114–6.
22. Torricelli FC, Marchini GS, Pedro RN, Monga M. Ureteroscopy for management of stone disease: an up to date on surgical technique and disposable devices. Minerva Urol Nefrol. 2016;68(6):516–26.
23. Vij DR, Mahesh K. Medical applications of laser. In: Technology & Engineering. Springer: Science & Business Media; 2013.
24. Brisbane W, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. Nat Rev Urol. 2016;13:654–62.
25. Perez Castro E, Osther PJ, Jinga V, *et al*. Differences in ureteroscopic stone treatment and outcomes for distal, mid-, proximal, or multiple ureteral locations: the Clinical Research Office of the Endourological Society ureteroscopy global study. Eur Urol. 2014;66:102.
26. Hyams E, Monga M, Pearle MS, *et al*. A prospective, multiinstitutional study of flexible ureteroscopy for proximal ureteral stones smaller than 2 cm. J Urol. 2015;193:165.
27. Mi Y, Ren K, Huang Y, *et al*. Flexible Ureterorenoscopy (F-URS) with Holmium laser versus Extracorporeal Shock Wave Lithotripsy (ESWL) for treatment of renal stone <2 cm: a meta-analysis. Urolothiasis. 2016;44:353–65.
28. Ito H, Sakamaki K, Matsuzaki J, *et al*. Development and validation of a nomogram for predicting stone-free status after flexible ureteroscopy for renal stones. BJU Int. 2014;115:446–551.
29. Bryniarski P, Paradysz A, Zyczkowski M, *et al*. A randomized controlled study to analyze the safety and efficacy of percutaneous nephrolithotripsy and retrograde intrarenal surgery in the management of renal stones more than 2 cm in diameter. J Endourol. 2012;26:52.
30. Moses RA, Ghali FM, Vernon MPJ, Hyams E. Unplanned hospital return for infection following ureteroscopycan we identify modifiable risk factors? J Urol. 2016;195(4):931–6.
31. Aboumarzouk O, Monga M, Kata S, Traxer O, Somani M. Flexible ureteroscopy and laser lithotripsy for stones >2 cm: a systematic review and meta-analysis. J Endourol. 2012;26:10.
32. Al-Qahtani SM, Gil-Deiz-de-Medina S, Traxer O. Predictors of clinical outcomes of flexible ureterorenoscopy with holmium laser for renal stone greater than 2 cm. Adv Urol. 2012, 543537
33. Cohen J, Cohen S, Grasso M. Ureteropyeloscopic treatment of large, complex intrarenal and proximal ureteral calculi. BJU Int. 2013;111:E127–31.
34. Hyams ES, Munver R, Bird VG, Uberoi J, Shah O. Flexible ureterorenoscopy and holmium laser lithotripsy for the management of renal stone burdens that measure 2 to 3 cm: a multiinstitutional experience. J Endourol. 2010;24:1583–8.
35. Preminger G. Management of lower pole calculi: shock wave lithotripsy versus percutaneous nephrolithotomy versus flexible ureteroscopy. Urol Res. 2006;34:108–11.
36. Sampaio FJ, Aragao AH. Inferior pole collecting system anatomy: its probable role in extracorporeal shock wave lithotripsy. J Urol. 1992;147(2):322–4.
37. Resorlu B, Oguz U, Resorlu EB, Oztuna D, Unsal A. The impact of pelvicaliceal anatomy on the success of retrograde intrarenal surgery in patients with lower pole renal stones. J Urol. 2012;79(1):61–6.
38. Singh BP *et al*. Retrograde intrarenal surgery vs extracorporeal shock wave lithotripsy for intermediate size inferior pole calculi: a prospective assessment of objective and subjective outcomes. Urology. 2014;83:1016–22.
39. El-Nahas AR, Ibrahim HM, Youssef RF, Sheir KZ. Flexible ureterorenoscopy versus extracorporeal shock wave lithotripsy for treatment of lower pole stones of 10–20 mm. BJU Int. 2012;110(6): 898–902.
40. Ghani KR, Wolf Jr JS. What is the stone-free rate following flexible ureteroscopy for kidney stones? Nat Rev Urol. 2015;12(7):363.
41. Borghi L, Meschi T, Amato F, Briganti A, Novarini A, Giannini A. Urinary volume, water and recurrences in idiopathic calcium nephrolithiasis: a 5-year randomized prospective study. J Urol. 1996;155(3):839–43.
42. Curhan GC, Willett WC, Rimm EB, Stampfer MJ. A prospective study of dietary calcium and other nutrients and the risk of symptomatic kidney stones. NEJM. 1993;328:833–8.
43. Taylor EN, Fung TT, Curhan GC. DASH-style diet associates with reduced risk for kidney stones. J Am Soc Nephrol. 2009;20(10): 2253–9.
44. Uribarri J, Oh MS, Carrol HJ. The first kidney stone. Ann Intern Med. 1989;111(12):1006.
45. Molina WR, Marchini GS, Monga M, *et al*. Determinants of holmium:yttrium-aluminum-garnet laser time and energy during ureteroscopic laser lithotripsy. Endourol Stones. 2014;83(4):738– 44.
46. Ackerman A, Chen T, Young B, Lipkin M, *et al*. The effect of variable pulse duration on stone communition, fiber tip degradation, and stone retropulsion in a “Dusting” model. J Urol. 2016;195(4S):e472–3.

47. Schatloff O, Lindner U, Ramon J, Winkler H. Randomized trial of stone fragment active retrieval versus spontaneous passage during holmium laser lithotripsy for ureteral stones. J Urol. 2010;183: 1031–5.
48. Portis A, Laliberte M, Drake S, Rosenberg M, Bretzke C. Intraoperative fragment detection during percutaneous nephrolithotomy: evaluation of high magnification rotational fluoroscopy combined with aggressive nephroscopy. J Urol. 2006;175: 162–5.
49. Rebuck DA, Macejko A, Bhalani V, Ramos P, Nadler RB. The natural history of renal stone fragments following ureteroscopy. Urology. 2011;77:564–8.
50. Hussain M, Acher P, Penev B, Cynk M. Redefining the limits of flexible ureterorenoscopy. J Endourol. 2011;25:45–9.
51. Cocuzza M *et al*. Outcomes of flexible ureteroscopic lithotripsy with holmium laser for upper urinary tract calculi. Int Braz J Urol. 2008;34:143–9.
52. Auge BK, Pietrow PK, Lallas CD, Raj GV, Santa-Cruz RW, Preminger GM. Ureteral access sheath provides protection against elevated renal pressures during routine flexible ureteroscopic stone manipulation. J Endourol. 2004;18(1):33–6.
53. Zhong W, Leto G, Wang L, Zeng G. Systemic inflammatory response syndrome after flexible ureteroscopic lithotripsy: a study of risk factors. J Endourol. 2015;29(1):25–8.
54. Ng YH, Somani BK, Dennison A, Kata SG, Nabi G, Brown S. Irrigant flow and intrarenal pressure during flexible ureteroscopy: the effect of different access sheaths, working channel instruments, and hydrostatic pressure. J Endourol. 2010;24(12):1915–20.
55. Kourambas J, Byrne RR, Preminger GM. Does a ureteral access sheath facilitate ureteroscopy? J Urol. 2001;165(3):789–93.
56. Pietrow PK, Auge BK, Delvecchio FC, Silverstein AD, Weizer AZ, Albala DM, *et al*. Techniques to maximize flexible ureteroscope longevity. Urology. 2002;60(5):784–8.
57. Berquet G, Prunel P, Verhoest G, Mathieu R, Bensalah K. The use of a ureteral access sheath does not improve stone-free rate after ureteroscopy for upper urinary tract stones. World J Urol. 2014;32: 229–32.
58. L'Esperance JO, Ekeruo WO, Scales Jr CD, *et al*. Effect of ureteral access sheath on stone-free rates in patients undergoing ureteroscopic management of renal calculi. Urology. 2005;66: 252–5.
59. Lallas CD, Auge BK, Raj GV, *et al*. Laser Doppler flowmetric determination of ureteral blood flow after ureteral access sheath placement. J Endourol. 2002;16:583–90.
60.• Traxer O, Thomas A. Prospective evaluation and classification of ureteral wall injuries resulting from insertion of a ureteral access sheath during retrograde intrarenal surgery. J Urol. 2013;189:580–4. **Large prospective study for renal stones treated by URS LL. With placement of a 12/14 Fr UAS. 46.5% had visible ureter damage on 4 point scale. Of these, 86% of which had mucosal injury and 10% with damage through mucosa to smooth muscle. Absence of pre-operative double-J stent placement was the greatest risk factor for ureteral injury.**
61. Delvecchio FC, Auge BK, Brizuela RM, *et al*. Assessment of stricture formation with the ureteral access sheath. Urology. 2003;61: 518–22.
62. Traxer O, Wendt-Nordahl G, de la Rosette JJ, *et al*. Differences in renal stone treatment and outcomes for patients treated either with or without the support of a ureteral access sheath: the clinical research office of the endourological society ureteroscopy global study. World J Urol. 2015;33:2137–44.
63. Morgan MSC, Antonelli JA, Pearle MS, *et al*. Use of an electronic medical record to assess patient-report morbidity following ureteroscopy. J Endourol. 2016;30(S1):S45–51.
64. Schuster TG, Hollenbeck BK, Faerber GJ, Wolf Jr JS. Ureteroscopic treatment of lower pole calculi: comparison of lithotripsy in situ and after displacement. J Urol. 2002;168:43–5.
65. Chew BH *et al*. Dusting versus basketing during ureteroscopic lithotripsy—what is more efficacious? Interim analysis from a multicentre prospective trial from the EDGE Research Consortium [abstract]. J Urol. 2015;193(4S):e261–2.
66. Gamal W, Mamdouh A. Flexible URS Holmium laser stone dusting vs fragmentaion for <2 cm single renal stone [abstract]. J Urol. 2015;193(4S):e312–3.
67. Tracey J, Gagin G, Ghani K, *et al*. Flexible ureteroscopy and laser lithotripsy for renal stones using 'pop-dusting': comparison of outcomes between traditional dusting settings versus ultra-high frequency settings [abstract]. J Urol. 2016;195(4S):e683.
68.•• Chew BH *et al*. Dusting versus basketing during ureteroscopic lithotripsy—what is more efficacious? final results from the EDGE Research Consortium [abstract]. J Urol. 2016;195(4S):e407. **Prospective comparison of dusting to basketing for renal stones 5–20 mm. Initial data shows lower SFR and higher residual fragments in the dusting arm with similar post-operative complications and re-interventions. However, final data analysis is not yet available.**

69. Candau C, Saussine C, Lang H, Roy C, Faure F, Jacqmin D. Natural history of residual renal stone fragments after ESWL. Eur Urol. 2000;37(1):18–22.
70. Streem SB, Yost A, Mascha E. Clinical implications of clinically insignificant store fragments after extracorporeal shock wave lithotripsy. J Urol. 1996;155(4):1186–90.
71. Osman MM, Alfano Y, Kamp S, *et al*. 5-Year follow-up of patients with clinically insignificant residual fragments after extracorporeal shock wave lithotripsy. Eur Urol. 2005;47(6):860–4.
72. El-Nahas AR, El-Assmy AM, Madbouly K, *et al*. Predictors of clinical significance of residual fragments after extracorporeal shock wave lithotripsy for renal stones. J Endourol. 2006;20(11): 870–4.
73. Khaitan A, Gupta NP, Hemal AK, *et al*. Post-ESWL, clinically insignificant residual stones: reality or myth? Urology. 2002;59(1):20–4.
74. Zanetti G, Seveso M, Montanari E, *et al*. Renal stone fragments following shock wave lithotripsy. J Urol. 1997;158(2):352–5.
75.• Chew BH, Brotherhood HL, Sur RL, Humphreys MR. Natural history, complications and re-intervention rates of asymptomatic residual stone fragments after ureteroscopy: a report from the EDGE Research Consortium. J Urol. 2016;195(4):982–6. **232 patients with residual fragments >4 or <4 mm after URS LL for renal stones were evaluated for "stone events" and complications. Residual fragments >4 mm were more likely to grow (p<0.001), result in complications (p=0.039), and reinterventions (p=0.01). Subset analysis also suggests step-wise increase in morbidity with increasing residual fragment size >2 mm.**
76. Tracey J, Gagin G, Ghani K, *et al*. Stone dusting: outcomes of ureteroscopic lithotripsy using a multi-cavity high-power Holmium laser [abstract]. J Urol. 2016;195(4S):e510.

Source: Santiago, J.E., Hollander, A.B., Soni, S.D. *et al*. *Curr Urol Rep* (2017) 18: 32. https://doi.org/10.1007/s11934-017-0677-8.

Cystoscopic Ureteral Stent Placement: Techniques and Tips

Brian J. Linder[1,2], John A. Occhino[2]

Abstract

Introduction and Hypothesis: We present a video demonstrating technical considerations and tips for cystoscopic placement of external, lighted, and internal ureteral stents.
Methods: Cystoscopic ureteral stent placement is useful in cases where difficult pelvic periureter dissection is expected or encountered. In this video, we review cystoscopy basics, our approach to various types of retrograde stent placement, and performing retrograde pyelograms. Traditional external ureteral stent and lighted stent placement for prophylactic purposes are discussed, with attention to understanding stent markings, appropriate resistance, and steps for externalization. Internal, double-J ureteral stent placement with the use of fluoroscopy is initiated with placement of a guidewire. An open-ended ureteral catheter is advanced over the wire in the pelvic portion of the ureter, and a retrograde pyelogram is performed. The wire is reintroduced and the stent advanced to the renal pelvis under fluoroscopy. The proximal curl is confirmed to be in the appropriate position with fluoroscopy. The string attached to the stent is then cut and removed, the guidewire is removed, and the stent is deployed with the distal curl in the bladder.
Conclusions: This video reviews key steps for cystoscopic ureteral stent placement in a prophylactic setting, cases of challenging anatomy, or ureteral injury.

Keywords Cystoscopy, Ureteral stent, Retrograde pyelogram, Ureteral injury

Electronic supplementary material The online online version of this article (https://doi.org/10.1007/s00192-018-3762-8) contains supplementary material. This video is also available to watch on http://link.springer. com/. Please search for this article by the article title or DOI number, and on the article page click on 'Supplementary Material'.

Brian J. Linder (✉)
e-mail: Linder.Brian@mayo.edu
[1]Department of Urology, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, USA
[2]Department of Obstetrics and Gynecology, Mayo Clinic, Rochester, MN, USA

Introduction

Ureteral injury is a potentially serious complication of pelvic surgery, with an estimated rate of 0.4–2.5% during benign gynecologic surgery [1]. This risk may be increased in cases of large pelvic masses, endometriosis, advanced malignancy, pelvic inflammatory disease, or previous radiation [2]. In cases where difficult periureteral dissection is anticipated, selective preoperative ureteral stent placement may aid in intraoperative ureteral identification, dissection of the ureter, and intraoperative identification of an injury should one occur [2, 3]. The latter is an important consideration, as early identification decreases perioperative morbidity and mortality [4]. Additionally, when minor ureteral injuries or ureteral obstruction is encountered, ureteral stent placement provides decompression, preservation of renal function, and allows for adequate healing [5]. In this setting, performing a retrograde pyelogram to guide stent placement is an important consideration. Blind stent placement in the setting of injury or obstruction can worsen the degree of ureteral injury or lead to ureteral perforation. To familiarize pelvic surgeons with various methods for cystoscopic ureteral stent placement, we present a video highlighting several techniques and tips.

Materials and Methods

We start with a review of basic cystoscopy, including cystoscope assembly. The cystoscope is composed of three components: a lens, a working port, and a sheath. For stent placement, we prefer using a 70° lens, with the working ports attached to an Albarran bridge to allow deflection of the wire or stent, and a 22-F sheath to accommodate stent passage.

Using a cadaveric specimen, we demonstrate techniques for traditional external stent placement (i.e., ureteral catheters), lighted ureteral stent placement, retrograde pyelography, and double-J ureteral stent placement. For traditional external ureteral stent placement, it is important to be cognizant of stent-length markings, which are visualized cystoscopically during stent placement. There should be minimal resistance during stent placement, before reaching the renal pelvis or an upper-pole calyx. If resistance is encountered before this, stent advancement without fluoroscopy should be stopped, as a mucosal flap or ureteral perforation may occur. In this setting, a retrograde pyelogram should be considered for guiding stent placement (internal or external). The process can then be repeated as needed for bilateral stent placement. Once the stents are in place, the remainder of the stent can be externalized, secured to a Foley catheter, and placed to drainage for monitoring during the case.

Lighted ureteral stents are external stents that emit infrared light in either a continuous or intermittent fashion from a powered filament within the stent lumen. They may be useful in laparoscopic or robotic cases given less tactile feedback. For placement, a 0.035 sensor-tip guidewire is advanced up the ureter until gentle resistance is felt proximally in the kidney, usually an upper-pole calyx. With the wire in place, the transparent open-ended ureteral catheter sheath is placed over the guidewire and advanced, with careful attention to the stent markings. The wire is then removed, and the ureteral catheter sheath is externalized and secured to a Foley catheter in a similar fashion to traditional external ureteral stent placement. Once secured, a light fiber is connected to a power source and advanced through the transparent sheath, and the stent can be illuminated during the pelvic portion of the surgery.

Internal double-J ureteral stent placement can be used prophylactically when one expects distorted pelvic anatomy and there is a need to retain the stent temporarily in the postoperative period or in the event of ureteral obstruction or minor injury. Here, an appropriate indwelling ureteral stent length must be selected, as the position of the distal stent curl (across the midline) has been associated with greater stent-related discomfort and voiding symptoms [6]. Several methods can be used to estimate the appropriate stent length [7–9]. It can be estimated from measuring the distance from renal pelvis to ureteral insertion on the coronal view of a computed tomography (CT) scan, directly measured with a ureteral catheter, or estimated using the patient's height (formula: height in inches minus 42 for adults, or height category: 5 ft. 10 in. to 6 ft. 4 in. predicted to need a 24-cm stent) [7–9]. Stent diameter has not been associated with the degree of stent-related discomfort, and most commonly, a 6- or 7-F stent is used [10].

Internal double-J stent placement typically includes use of fluoroscopy and retrograde pyelography and is initiated with placement of a 0.035 sensor-tip guidewire. After placement of the wire (or before if using a Rutner catheter) a retrograde pyelogram is performed. This allows evaluation of ureteral anatomy, assessment for contrast extravasation (which would be seen in a ureteral injury) and ureteral obstruction, and identifies filling defects (e.g., as would be seen with urolithiasis, urothelial cancer, or other space-occupying pathologies). If using a ureteral catheter for the pyelogram, the catheter is advanced over the wire in the distal pelvic portion of the ureter, the wire removed, contrast instilled through the ureteral catheter, and fluoroscopy used to carry out the retrograde pyelogram. The wire is then reintroduced and advanced to the renal pelvis. Using a push–pull technique, the ureteral catheter is removed while maintaining the wire in the renal pelvis. The stent is then advanced over the wire to the renal pelvis under cystoscopic and fluoroscopic guidance with use of a stent pusher. Cystoscopically, the surgeon can rely on markings on the outside of the stent to determine how far it has been advanced. Once it has been advanced to the renal pelvis, partially withdrawing the guidewire forms the proximal stent curl, which can be confirmed on fluoroscopy. A curl of at least 180° is preferred due to the risk of stent migration. If an inadequate curl is seen, the stent can be manipulated using the string attached to the distal portion and the stent pusher. Once an adequate proximal curl is confirmed, the string is cut and removed while the stent pusher is held to maintain stent position. The guidewire is then completely removed, the cystoscope pointed away from the ureteral orifice, and the pusher advanced to deploy the distal stent curl. The distal curl should also have at least a 180° curl, and, as noted above, should not cross the midline in the bladder [6].

Conclusions

A variety of techniques are available for cystoscopic ureteral stent placement both for prophylactic purposes and in the event of obstruction or injury. It is important that pelvic surgeons be familiar with these techniques, which may be useful when approaching challenging pelvic surgeries or inadvertent ureteral issues.

Compliance with ethical standards

Conflicts of interest None.

Consent Written informed consent was obtained from the patient for publication of this video article and any accompanying images.

References

1. Drake MJ, Noble JG. Ureteric trauma in gynecologic surgery. Int Urogynecol J Pelvic Floor Dysfunct. 1998;9:108.
2. Manoucheri E, Cohen SL, Sandberg EM, *et al*. Ureteral injury in laparoscopic gynecologic surgery. Rev Obstet Gynecol. 2012;5: 106.
3. Chou MT, Wang CJ, Lien RC. Prophylactic ureteral catheterization in gynecologic surgery: a 12-year randomized trial in a community hospital. Int Urogynecol J Pelvic Floor Dysfunct. 2009;20:689.
4. Delacroix SE Jr, Winters JC. Urinary tract injures: recognition and management. Clin Colon Rectal Surg. 2010;23:104.
5. Morey AF, Brandes S, Dugi DD III, *et al*. Urotrauma: AUA guideline. J Urol. 2014;192:327.
6. Al-Kandari AM, Al-Shaiji TF, Shaaban H, *et al*. Effects of proximal and distal ends of double-J ureteral stent position on postprocedural symptoms and quality of life: a randomized clinical trial. J Endourol. 2007;21:698.
7. Barrett K, Foell K, Lantz A, *et al*. Best stent length predicted by simple CT measurement rather than patient height. J Endourol. 2016;30:1029.
8. Kawahara T, Ito H, Terao H, *et al*. Which is the best method to estimate the actual ureteral length in patients undergoing ureteral stent placement? Int J Urol. 2012;19:634.
9. Pilcher JM, Patel U. Choosing the correct length of ureteric stent: a formula based on the patient's height compared with direct ureteric measurement. Clin Radiol. 2002;57:59.
10. Erturk E, Sessions A, Joseph JV. Impact of ureteral stent diameter on symptoms and tolerability. J Endourol. 2003;17:59.

Source: Linder, B.J. & Occhino, J.A. *Int Urogynecol J* (2019) 30: 163. https://doi.org/10.1007/s00192-018-3762-8.

A Large Bladder Stone Caused by the Intravesical Migration of an Intrauterine Contraceptive Device: A Case Report

W. S. L. De Silva[1]*, K. A. S. U. A. Kodithuwakku[1], G. U. E. Aponsu[2], R.M.M. Rathnayake[2], E. Rajasegaram[2]

Abstract

Background: A wide variety of complications due to the extrauterine migration of intrauterine contraceptive devices have been reported in the literature. Here we describe the case of a large bladder stone formed around a migrated Copper T380A device that was neglected and detected 15 years after insertion.

Case presentation: A 48-year-old Sri Lankan woman underwent a workup for lower urinary tract symptoms and recurrent urinary tract infections over the previous 6 months. The radiographs showed a large bladder stone with an imprint of an intrauterine contraceptive device in the center of it. The device had been inserted 15 years previously. Two years after the insertion, it was considered to be missing, but our patient did not comply with the recommended follow-up. She had been completely asymptomatic until she developed lower urinary tract symptoms. After confirming the location of the stone via ultrasonography, a vesicolithotomy was performed, revealing a stone with three limbs corresponding to the shape of the Copper T380A device. The device and the threads were fully covered with the stone material. Our patient was asymptomatic following the surgery.

Conclusions: A migrated intrauterine contraceptive device can act as the nidus for the formation of a secondary bladder stone. The detailed imprint of the device inside the stone and the laminated appearance of the stone material were characteristic of a secondary bladder stone formed around an intrauterine contraceptive device. Radiography and ultrasonography are adequate for the diagnosis of intravesical migration of intrauterine contraceptive devices.

***Correspondence:** supun85@gmail.com
[1]Post Graduate Institute of Medicine, University of Colombo, Colombo, Sri Lanka

Full list of author information is available at the end of the article

Keywords: Secondary bladder stone, Intrauterine contraceptive device, Transmigration of an intrauterine contraceptive device, Case report

Background

Vesicolithiasis is a rare condition in an otherwise normal bladder that can be caused by outflow obstruction, chronic or recurrent infections, and intravesical foreign bodies [1]. A rare iatrogenic cause of vesicolithiasis (bladder stones) is a migrated intrauterine contraceptive device (IUCD). IUCDs are known for uterine perforation and extrauterine migration, with perforations being reported at a rate of 1.2 to 1.6 per 1000 IUCD insertions [2]. The most common sites for IUCD migration are the omentum, rectum, sigmoid colon, peritoneum, and bladder [3]. The nature of symptoms caused by the migration depends on the destination of the device. Transvesical migration usually results in lower urinary tract symptoms, even in the absence of a secondary bladder stone.

Here we have described the asymptomatic migration of an IUCD, previously considered to be missing, resulting in the formation of a large secondary bladder stone detected 15 years after the insertion. A plain X-ray was characteristic in showing the layers of stone material laid down around the limbs of the IUCD and an ultrasound scan was useful in confirming the location of the stone. Even though computed tomography is recommended for the localization of a missing IUCD, a plain radiograph and ultrasound scan was adequate in this case. The prolonged asymptomatic period observed in this case has resulted in the formation of a large stone and delayed the seeking of medical care.

Case Presentation

A 48-year-old Sri Lankan woman was referred to our general surgical clinic for the management of a bladder stone following successful treatment for a urinary tract infection complicated with upper tract involvement. She complained of intermittent nonspecific lower abdominal pain, dysuria, and hematuria over the previous 6 months. During the same period of time she had three uncomplicated urinary tract infections that were managed by her general practitioner. The urine culture grew a pure growth of *Proteus* each time. She was managed with orally administered co-amoxiclav, according to the antibacterial sensitivity report, for 1 week during each episode. She was put on nitrofurantoin as a urinary antiseptic after the third episode of urinary tract infection. On presentation for the complicated, fourth urinary tract infection, this case underwent further investigation. She was found to be septic with a heart rate of 110 beats/minute, blood pressure of 130/90 mmHg, temperature of 38.9 °C (102 °F), and respiratory rate of 20/minute. She had neutrophil leukocytosis (18×10^9/ml), but her liver and renal function tests were normal. The radiographs of her kidney, ureter, and bladder showed a large bladder stone with three limbs and an imprint of a typical Copper T380A IUCD (Pregna International Ltd., Mumbai, India) in the middle of the stone (Fig. 1). An ultrasound scan of her kidney, ureter, and bladder confirmed the intravesical location of the stone and left-side pyelonephritis. Urine culture yielded a mixed growth of coliform and *Proteus*. She was managed with intravenously administered cefotaxime according to the antibacterial sensitivity report for 1 week and was continued on the nitrofurantoin until she underwent surgery.

On further inquiry, our patient indicated that she had an IUCD inserted 15 years previously, after the delivery of her third child. Two years later, the threads of the IUCD could not be found during a routine visit to a Well Woman Clinic, and it was documented as a missing IUCD. A further workup was not conducted since she did not return for a follow-up. She had forgotten about the missing IUCD and only mentioned it after being questioned. She denied having any urinary or lower abdominal symptoms until the last 6 months. She did not have any previous medical conditions. She was a housewife and had no other risk factor for urolithiasis. She had no family history of urolithiasis. Her general and abdominal examinations were otherwise unremarkable.

The diagnosis of a bladder stone formed around a migrated IUCD was made and an open vesicolithotomy was scheduled for 4 weeks later due to the large size of the stone. The vesicolithotomy was uncomplicated, and the interior of her bladder was normal. A large bladder stone with three limbs measuring 6 × 5 cm was removed, the stone was broken, and the IUCD was found inside. The three limbs of the stone were shaped to cover the three limbs of the IUCD, with the threads of the device also completely covered by the stone material (Fig. 2). Her postoperative period was uncomplicated and she was asymptomatic after the removal of the stone. At 6 months there were no further attacks of urinary tract infections.

Discussion

The transmigration of an IUCD occurs due to traumatic primary perforation of the uterus or due to a long-term inflammatory process, the exact mechanism of which is not fully understood. The copper contained in some IUCDs can mount an inflammatory reaction that results in the contraceptive effect, but it can also be involved in the process of long-term uterine perforation and transmigration [4]. In this case, our patient could feel the threads of the IUCD during the first 2 years after insertion, but later was diagnosed as having a missing IUCD. Moreover, she did not adhere to the recommended follow-up. The perforation of the bladder wall or the mere presence

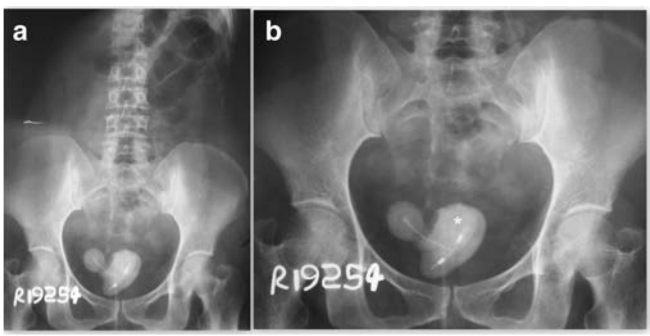


Fig. 1: Plain radiographs. **a** The imprint of the intrauterine contraceptive device is seen in the center of the stone. **b** A magnified view of the Xray showing the characteristic laminated appearance of the stone due to the concentric layers of stone material deposited around the intrauterine contraceptive device (*).

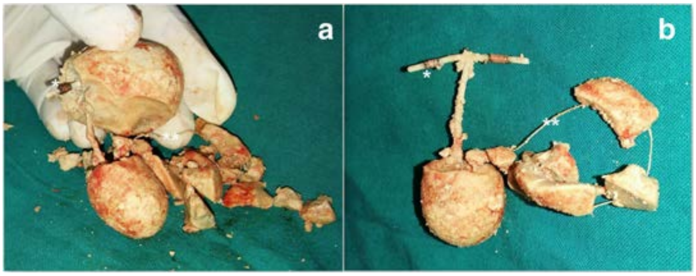


Fig. 2: Features of the stone. **a** and **b** The copper coil (*) and the threads (**) of the intrauterine contraceptive device after breaking the stone.

of a foreign body, like an IUCD, can cause an array of lower urinary tract symptoms. Our patient did not have any symptoms over the 13 years prior to this incidence, and all of her presenting symptoms could be attributed to the presence of a large bladder stone alone. Thus, this is a case of the chronic asymptomatic migration of an IUCD into the bladder, which was discovered only after our patient became symptomatic due to the secondary stone. The imprint of the IUCD on the stone and the concentric layers of stone material noted around the IUCD in the X-ray films of our patient are characteristic of a secondary stone formed around a migrated IUCD. These two features could be seen clearly in a similar case reported by Amin and Mahmood [5]. The radiographs and ultrasonography were adequate to make the diagnosis in this case, as well as in similar cases with intravesical migration [5, 6]. However, for IUCDs lodged in other areas of the body, computed tomography may be necessary for proper localization.

The nature of the complications from a migrated IUCD depends mainly on its destination. Cases of both intraperitoneal and extraperitoneal migration locations have been reported. The omentum is the most common lodging site after intraperitoneal migration. A wide variety of complications have been reported due to such intraperitoneal IUCDs; for example, Weerasekera *et al*. reported a case of a sigmoid colocolic fistula due to an intraperitoneal IUCD [7]. Moreover, the bladder, rectum, and ureter are reported extraperitoneal IUCD migration sites. Several cases of intravesical migration have been previously reported, and a number of them have resulted in vesicolithiasis [5, 6, 8–11]. Rectal perforation [12] and ureteric erosion [13] caused by migrated IUCDs have also been reported.

In this case, the complex etiology of our patient's bladder symptoms became clear only after performing the relevant imaging and taking a thorough history. Bladder symptoms due to an IUCD can also arise from the partial invasion of the bladder wall without transmigration [8]. Thus, a high index of suspicion should be kept in mind when managing patients with either *in situ* or missing IUCDs complaining of bladder symptoms. Moreover, this highlights the importance of arranging proper workups for all patients with missing IUCDs. The removal of a migrated IUCD after proper localization is advisable because of the unpredictability of the natural history.

Conclusions

A migrated IUCD can act as the nidus for the formation of a secondary bladder stone. A high index of suspicion should be kept in mind when managing patients with missing IUCDs complaining of bladder symptoms. The detailed imprint of the device inside the stone and the laminated appearance of the stone material were characteristic of a secondary bladder stone formed around an IUCD. Radiography and ultrasonography are adequate for the diagnosis of intravesical migration of IUCDs.

Abbreviation
IUCD: Intrauterine contraceptive device

Acknowledgements
The authors wish to acknowledge the support extended by the staff of Ward-02 and Operating theatre-A of the District General Hospital Kalutara in preparing the figures of this article.

Funding
No funding was received for this study.

Availability of data and materials
Not applicable.

Authors' contributions
WSLD followed up with the patient, compiled the patient details, prepared figures, and wrote the manuscript. ER, WSLD, KASUAK, GUEA, and RMMR were involved in decision making, surgery, and perioperative management. ER revised and restructured the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate
Ethical approval for the publication of this case report was obtained from the Ethics Review Committee of the District General Hospital Kalutara.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests
The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

[1]Post Graduate Institute of Medicine, University of Colombo, Colombo, Sri Lanka. [2]General Surgery Unit, District General Hospital Kalutara, Nagoda, Sri Lanka.

References

1. Yoshida O, Okada Y. Epidemiology of urolithiasis in Japan: a chronological and geographical study. Urol Int. 1990;45(2):104–11.
2. Harrison-Woolrych M, Ashton J, Coulter D. Uterine perforation on intrauterine device insertion: is the incidence higher than previously reported? Contraception. 2003;67:53–6.
3. Kassab B, Audra P. The migrating intrauterine device. Case report and review of the literature. Contracept Fertil Sex. 1999;27(10):696–700.
4. Kaneshiro B, Aeby T. Long-term safety, efficacy, and patient acceptability of the intrauterine Copper T-380A contraceptive device. Int J Women's Health. 2010;2:211–20.
5. Amin U, Mahmood R. An Unusual Vesical Calculus. J Radiol Case Rep. 2009; 3(2):10–3. doi:10.3941/jrcr.v3i2.113.
6. Vagholkar S, Vagholkar K. Secondary Vesical Calculus Resulting from Migration of an Intrauterine Contraceptive Device. Case Rep Obstet Gynecol. 2012;2012:603193. doi:10.1155/2012/603193.

7. Weerasekera A, Wijesinghe P, Nugaduwa N. Sigmoid colocolic fistula caused by intrauterine device migration: a case report. J Med Case Rep. 2014;8:81.
8. Sharma A, Andankar M, Pathak H. Intravesical Migration of an Intrauterine Contraceptive Device with Secondary Calculus Formation. Korean J Fam Med. 2017;38(3):163–5. doi:10.4082/kjfm.2017.38.3.163.
9. Aggarwal S, Jindal RP, Deep A. Intravesical Migration of Intrauterine Contraceptive Devices with Stone Formation. J Fam Med Prim Care. 2014; 3(4):449–51. doi:10.4103/2249-4863.148147.
10. Abdulwahab-Ahmed A, Ogunleye OO. Vesical Calculus 10 Years Post Missing Intrauterine Contraceptive Device. J Surg Tech Case Rep. 2013;5(1): 48–50. doi:10.4103/2006-8808.118630.
11. Dietrick DD, Issa MM, Kabalin JN, Bassett JB. Intravesical migration of intrauterine device. J Urol. 1992;147:132–4.
12. Abasiattai AM, Umoiyoho AJ, Utuk NM, Ugege W, Udoh IA. Intrauterine contraceptive device with rectal perforation and strings presenting at the anus. BMJ Case Reports. 2010;2010:bcr0320102836. doi:10.1136/bcr.03.2010.2836.
13. Priyadarshi V, Sehgal N, Sen D. Ureteric erosion and obstruction: A rare but dreaded complication of intrauterine contraceptive device. Urol Ann. 2017;9:103–6.

Source: De Silva, W.S.L., Kodithuwakku, K.A.S.U.A., Aponsu, G.U.E. *et al*. *J Med Case Reports* (2017) 11: 293. https://doi.org/10.1186/s13256-017-1461-6. © The Author(s). 2017.

Notes: