



ORIGINAL ARTICLE

Ureteroscopic treatment of larger renal calculi (> 2 cm)

Demetrius H. Bagley ^{*}, Kelly A. Healy, Nir Kleinmann

Department of Urology, Thomas Jefferson University, Philadelphia, PA, USA

Received 10 April 2012, Received in revised form 10 May 2012, Accepted 14 May 2012
Available online 19 July 2012

KEYWORDS

Kidney;
Calculi;
Ureteroscopy;
Lithotripsy

ABBREVIATIONS

PCNL, percutaneous nephrolithotomy; CRI, chronic renal insufficiency; UL, ureteroscopic lithotripsy; UAS, ureteric access sheath

Abstract **Objectives:** To evaluate the current status of ureteroscopic lithotripsy (UL) for treating renal calculi of > 2 cm, as advances in flexible ureteroscope design, accessory instrumentation and lithotrites have revolutionised the treatment of urinary calculi. While previously reserved for ureteric and small renal calculi, UL has gained an increasing role in the selective management of larger renal stone burdens.

Methods: We searched the available databases, including PubMed, Google Scholar, and Scopus, for relevant reports in English, and the article bibliographies to identify additional relevant articles. Keywords included ureteroscopy, lithotripsy, renal calculi, and calculi > 2 cm. Retrieved articles were reviewed to consider the number of patients, mean stone size, success rates, indications and complications.

Results: In all, nine studies (417 patients) were eligible for inclusion. After one, two or three procedures the mean (range) success rates were 68.2 (23–84)%, 87.1 (79–91)% and 94.4 (90.1–96.7)%, respectively. Overall, the success rate was > 90% with a mean of 1.2–2.3 procedures per patient. The overall complication rate was 10.3%, including six (1.4%) intraoperative and 37 (8.9%) postoperative complications, most of which were minor. The most common indications for UL were a failed previous treatment (46%), comorbidities (18.2%), and technical and anatomical factors (12.3%).

Conclusions: UL is safe and effective for treating large renal calculi. While several procedures might be required for total stone clearance, UL should be considered a standard approach in the urologist's options treating renal calculi of > 2 cm.

© 2012 Arab Association of Urology. Production and hosting by Elsevier B.V.
All rights reserved.

* Corresponding author.

E-mail address: demetrius.bagley@jefferson.edu (D.H. Bagley).

Peer review under responsibility of Arab Association of Urology.



Production and hosting by Elsevier

Introduction

The treatment of urinary calculi has advanced considerably with the development of instruments and techniques. Most patients with renal and ureteric calculi presenting to a urologist require treatment. The cur-

rently available options include ESWL, percutaneous nephrolithotomy (PCNL), and ureteroscopic lithotripsy (UL). Open and laparoscopic surgery are reserved for rare, special cases [1,2].

Once the decision to treat the stone has been made there must be a decision on which technique to use. This is based on the success and the morbidity of any individual procedure, which in turn is based on the location and size of the stone, as well as the patient's comorbidities. While ESWL is the least invasive approach it is also generally the least successful [3]. Percutaneous approaches are typically used for treating large renal stones. PCNL is associated with a higher success rate but it also has a higher complication rate [4,5]. The success of UL within the ureter has been transferred to the kidney and become widely accepted [6,7]. It has had some limitations for large stones, which have been investigated more widely recently. Here we review previous reports to define the status of UL for renal calculi of > 2 cm in diameter.

Methods

We systematically reviewed reports in English using a search of the standard databases PubMed, Google Scholar and Scopus. Full-text papers between 1983 and 2012 were included. We also used our ongoing bibliography of pertinent reports. Keywords included 'ureteroscopy', 'lithotripsy', 'renal calculi', and 'calculi > 2 cm'. The articles retrieved were reviewed to consider the number of patients, the mean size of the stones, the success rate after one, two or three procedures, and the indications and complications if reported.

We accepted the authors' definition of success, whether it was stone-free or fragments of < 2, < 3, or < 4 mm. We also accepted their defining study of plain abdominal radiography, IVU, ultrasonography or CT, or a 'second look' ureteroscopy.

Results

Nine studies met the inclusion criteria [8–16]; collectively in these series, 417 patients were treated ureteroscopically

for stones of > 2 cm in diameter. Some studies subdivided them further for stones of > 3 cm. Various reports presented the data in different forms, some of which could not be reformatted into the selected format. Different criteria for success were used in some papers and we did not subdivide them.

The success in clearing stones ureteroscopically varied by the number of procedures and by the size of the stones (Table 1) [8–15]. In each series the success increased as patients were treated in one to three episodes. The mean (range) success rate after one procedure was 88.2 (23–84)%. After a second procedure the success rate was 79–91%. All series reported a success rate of > 90% after three procedures. Overall, the mean success rate was 94.4% with a mean of 1.2–2.3 procedures per patient.

The definition of successful treatment also varied among studies. Most commonly success was defined as stone-free or residual fragments of < 3 mm. There was a wide variation in success rate related to this definition. Hyams et al. [13] showed that the defined success increased from 47% for stone-free to 66% for fragments of 0–2 mm and 83% if fragments of < 4 mm were acceptable.

The duration of the procedures is also summarised in Table 1 [9–15]. The range among the series reporting this information was 25–240 min, and the mean ranged from 66 to 135 min. In one series the duration of the procedure was separated into those for stones of 2–3 cm, which was 70 min, and those of > 3 cm, which was 135 min [9].

The overall complication rate was 10.3%, which included six (1.4%) intraoperative complications and 37 (8.9%) postoperative complications (Table 2) [8–16]. Although the vast majority of postoperative incidents were minor, five major complications were reported. This included one patient with haematuria requiring endoscopic treatment. Two patients developed obstructive pyelonephritis, again requiring treatment. One patient did not comply with the prescribed preoperative antibiotics and developed bacteraemia. Last, a cerebral vascular accident developed after surgery in one patient who had a strong history of vascular disease.

Table 1 UL for renal calculi; the success rate by procedure.

Reference	No. of patients	Stone size (cm)	Procedures, % success			Mean no. of procedures	Duration of procedure, min (range) {stone size, cm}
			1	2	3		
[8]	45 (renal)	> 2	76	91	93	1.2	—
[9]	30	> 2	77	ND	ND	1.0	70 (55–85) {2–3} 135 (75–160) {> 3}
[10]	13	2–4	77	84.6	92.3		66 (25–240) (47 min/stage)
[11]	15	2.0–2.5	66	93	93	2.3	83 (45–140)
[12]	22	> 2.5	23	86.3	90.1	1.82	72 (78–138)
[13]	120	2–3	84	NS	ND	—	74.3 (SD 20) {NS}
[14]	24	> 2	54	79	92	1.7	114 (50–215)
[15]	120	> 2	58.5	87	96.7	1.6	89 (60–140)
Mean%			68.2	87.1	94.4		

ND, not done; NS, not stated.

Table 2 Complications reported for the total of 417 patients [8–16].

Complication	n (%)
Intraoperative	6 (1.4)
Bleeding	3
Perforation	2
Fornix rupture	1
Postoperative	37 (8.9)
Gross haematuria	3
Fever	4
Steinstrasse	4
Subcapsular haematoma	1
UTI (Inc. simple pyelonephritis)	7
Obstructive pyelonephritis	2
Urinary retention	1
Prostatitis	2
Stent pain	3
Colic	1
Retention	1
Admission for observation	3
<i>Major</i>	
Haematuria	1
Obstructive pyelonephritis	2
Bacteraemia	1
Cerebrovascular accident	1

Most series reported specific indications for using a ureteroscopic procedure (Table 3) [8–15]. Among the summarised series the most common indication (46%) was a failed previous treatment, which included ESWL, endoscopic or medical treatment. The next most common indications were comorbidities (18.2%) and technical and anatomical indications (12.3%). In one series [12] all patients were treated at the surgeon's preference and another noted that the patient's preference was the basis for treatment in 48% of patients [13].

Discussion

The success reported with UL for large renal calculi has improved as a result of the continual development of

instruments and techniques. UL has been used for treating ureteric stones since its first introduction. The earliest ureteroscopes were rigid and 12–13 F, with only a rigid ultrasonic probe available [17]. As small-diameter rigid endoscopes and smaller flexible ureteroscopes were developed the success rate increased for treating stones in the proximal ureter and the intrarenal collecting system [18].

A major step in instrumentation was the introduction of the pulsed-dye and then the holmium lasers. These were found to be safe to use in the ureter and throughout the intrarenal collecting system [19–21]. One drawback is that the fibre must be in contact or extremely close to the targeted stone.

The electrohydraulic lithotripter (EHL) has probes as small as 1.7–1.9 F, which are extremely flexible and do not limit endoscope deflection. EHL yields excellent fragmentation and does not require direct contact with the stone. However, it must be used with caution, to avoid intrarenal bleeding [16]. Mariani [22] used it as the primary lithotripter in his series of intrarenal calculi, with favourable outcomes.

The working devices continued to develop; prominent among these are the Nitinol basket, which is more flexible than stainless-steel baskets and easier to use than wire-pronged graspers. It is easy to engage and disengage with this basket. Therefore, it could be used in the entire collecting system [23–25].

Lower-pole calculi pose a unique challenge for UL. Traditionally, PCNL has been considered advantageous for treating large lower-pole stones, but recent series showed that UL achieves comparable outcomes [26]. Again, this has become possible with advances in ureteroscope design, accessory instrumentation and improved techniques. Smaller calibre flexible ureteroscopes with improved deflection characteristics allow the endourologist to reach nearly all areas of the intrarenal collecting system. Furthermore, small-diameter laser fibres (200 µm) are now available which minimally limit ure-

Table 3 The indications (n) for UL (357 patients).

Indication	Study						Mean (%)
	[8]	[16]	[12]	[13]	[14]	[15]	
No. of patients	45	23	22	120	24	123	
Mean% failed ESWL/PCNL/medical*	29	14	—	9	11	82	46.2
Comorbidity	12	17	—	17	3	16	18.2
Technical or	7	7	—	24	4	2	12.3
Anatomical	—	—	—	3	—	14	4.7
Body habitus	NS	3	—	3	—	9	4.2
Solitary kidney	8	3	—	—	—	NS	3.1
CRI	—	2	—	2	3	3	2.5
Anticoagulation	2	—	2	—	—	—	1.1
Other	—	NS	22	57	3	NS	22.9

NS, not stated.

* > 100% as some patients were listed for more than one indication.

teroscope deflection. More flexible working devices are also being developed [26]. Additional strategies for lower-pole calculi include use of alternative lithotrites such as EHL and use of a basket for stone relocation.

Among the studies included in this review, 105 patients of 412 had strictly lower-pole stones. An additional 91 patients had multifocal stones, which presumably included some patients with a lower-pole component. However, most studies only reported the overall stone-free rates. Of the three studies that stratified stone-free rates based on stone location, the reported lower-pole stone clearance rate was 83–100% [11,14,16]. While multiple procedures might be required, the final outcome can be equivalent to that of PCNL but with a lower risk of morbidity [5].

Although commonly used for treating large renal calculi the use of a ureteric access sheath (UAS) is not universal and remains controversial. The UAS has been purported to improve irrigant flow and visibility, and thereby prevent harmful increases in intrarenal pressure. The UAS also allows the passive egress of stone debris and facilitates the active retrieval of stone fragments. These benefits come at the cost of a larger size, and care must be taken to prevent ureteric injury when inserting the UAS. Similarly, there is controversy over the removal of fragments. Many authors fragment the stone into tiny pieces which they expect can pass, but remove one or more for chemical analysis. Others may choose to remove most of the fragments to minimise the volume of stone that the patient must pass [8,16].

These series of large (> 2 cm) renal calculi treated ureteroscopically show the success of this procedure and the low rate of complications. However, it might require more than one procedure to achieve the highest success rate. As noted in Table 1, one ureteroscopic procedure cleared the large stone in a mean of 68% of episodes. This increased to 87% with a second procedure and 94% in a third procedure.

Larger stones have also been treated by UL. The earliest series of stones of > 4 cm showed the potential utility of UL [27], but there was a 13.8% rate of sepsis. This might have been prevented with the preoperative use of antibiotics for a week, as shown for PCNL with infected stones [28]. Mariani [22] more recently reported the potential for UL with less morbidity.

UL must be compared with the other available methods, including ESWL and PCNL. ESWL is the least invasive and has become the most popular procedure for renal calculi. However, the success rate strongly depends on the size, location and composition of the stone. The need for repeat procedures and for ancillary procedures increases sharply as the stone increases from 1 to 2 cm in diameter [4]. When comparing ESWL to PCNL for stones of > 2 or 2.5 cm in diameter the evidence strongly supports the use of percutaneous procedures.

PCNL requires new access to the kidney and possibly several sites. Depending on the size of the tract developed, larger endoscopes up to 28 F can be used to deliver larger endoscopic lithotripters, such as the ultrasonic probe, to remove large volumes of stone expeditiously. Despite its high efficacy, PCNL is associated with increased morbidity, with the risks of bleeding, infection, other organ damage, as well as the discomfort of the procedure and the nephrostomy tube itself [5]. Simultaneous nephroscopy and retrograde ureteroscopy can give simultaneous access from two approaches without adding an additional nephrostomy [29–32].

There are very few studies directly comparing two or more techniques for stone treatment, and there are fewer for stones of > 2 cm in diameter. In a comparison of ESWL and PCNL the latter was much more successful but had more complications [33]. A comparison of ESWL and UL assessed only lower-pole stones of ≤ 1 cm. The authors reported a higher but not statistically significant stone-free rate for UL [34]. It is impossible to relate these findings directly to larger stones.

The high success rate and low morbidity of UL for stones of > 2 cm render it preferable to other methods, including ESWL and PCNL. It should be considered as a standard approach to treat large renal calculi.

Conflict of interest

No conflict of interest to declare.

Source of Funding

There was no source of funding for this article.

References

- [1] Keeley FX, Gialas I, Pillai M, Chrisofos M, Tolley DA. Laparoscopic ureterolithotomy. The Edinburgh experience. *BJU Int* 1999;84:765–9.
- [2] Miller SD, Ng CS, Streem SB, Gill IS. Laparoscopic management of caliceal diverticular calculi. *J Urol* 2002;167:1248–52.
- [3] Madaan S, Joyce AD. Limitations of extracorporeal shock wave lithotripsy. *Curr Opin Urol* 2007;17:109–13.
- [4] Lingeman JE, Siegel YI, Steele B, Nyhuis AW, Woods JR. Management of lower pole nephrolithiasis: a critical analysis. *J Urol* 1994;151:663–7.
- [5] Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. *Eur Urol* 2007;51:899–906.
- [6] Bagley DH. Removal of upper urinary tract calculi with flexible ureteropyeloscopy. *Urol* 1990;35:412–6.
- [7] Fabrizio MD, Behari A, Bagley DH. Ureteroscopic management of intrarenal calculi. *J Urol* 1998;159:1139–43.
- [8] Grasso M, Conlin M, Bagley DH. Retrograde ureteropyeloscopic treatment of 2 cm or greater upper urinary tract and minor staghorn calculi. *J Urol* 1998;160:346–51.
- [9] El-Anany FG, Hammouda HM, Maghraby HA, Elakkad MA. Retrograde ureteropyeloscopic holmium laser lithotripsy for large renal calculi. *BJU Int* 2001;88:850–3.

- [10] Mariani AJ. Combined electrohydraulic and holmium: YAG laser ureteroscopic nephrolithotripsy for 20–40 mm renal calculi. *J Urol* 2004;172:170–4.
- [11] Breda A, Ogunyemi O, Leppert JT, Lam JS, Schulam PG. Flexible ureteroscopy and laser lithotripsy for single intrarenal stones 2 cm or greater - is this the new frontier? *J Urol* 2008;179:981–4.
- [12] Riley JM, Stearman L, Troxel S. Retrograde ureteroscopy for renal stones larger than 2.5 cm. *J Endourol* 2009;23:1395–8.
- [13] Hyams E, Munver R, Bird V, Uberoi J, Shah O. Flexible ureterorenoscopy and holmium laser lithotripsy for the management of renal stone burdens that measure 2–3 cm: a multi-institutional experience. *J Endourol* 2010;24:1583–8.
- [14] Bader MJ, Gratzke C, Walter S, Weidlich P, Staehler M, Seitz M, et al. Efficacy of retrograde ureteropyeloscopic holmium laser lithotripsy for intrarenal calculi > 2 cm. *Urol Res* 2010;38:397–402.
- [15] 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;2012:543537.
- [16] Ricchiuti DJ, Smaldone MC, Jacobs BL, Smaldone AM, Jackman SV, Averch TD. Staged retrograde endoscopic lithotripsy as alternative to PCNL in select patients with large renal calculi. *J Endourol* 2007;21:1421–4.
- [17] Huffman JL, Bagley DH, Schoenberg HW, Lyon ES. Transurethral removal of large ureteral and renal pelvic calculi using ureteroscopic ultrasonic lithotripsy. *J Urol* 1983;130:31–4.
- [18] Bagley DH. Expanding role of ureteroscopy and laser lithotripsy for treatment of proximal ureteral and intrarenal calculi. *Curr Opin Urol* 2002;12:277–80.
- [19] Dretler SP. An evaluation of ureteral laser lithotripsy: 225 consecutive patients. *J Urol* 1990;143:267–72.
- [20] Erhard M, Salwen J, Bagley DH. Ureteroscopic removal of mid and proximal ureteral calculi. *J Urol* 1996;155:38–42.
- [21] Teichman JM. Laser lithotripsy. *Curr Opin Urol* 2002;12:305–9.
- [22] Mariani AJ. Combined electrohydraulic and holmium: YAG laser ureteroscopic nephrolithotripsy of large (> 2 cm) renal calculi. *Indian J Urol* 2008;24:521–5.
- [23] Blew BD, Dagnon AJ, Fazio LM, Pace KT, Honey RJ. Practical comparison of four nitinol stone baskets. *J Endourol* 2007;21:655–8.
- [24] Leone NT, Garcia-Roig M, Bagley DH. Changing trends in the use of ureteroscopic instruments from 1996 to 2008. *J Endourol* 2010;24:361–5.
- [25] Kesler SS, Pierre A, Brison DI, Preminger GM, Munver R. Use of the Escape nitinol stone retrieval basket facilitates fragmentation and extraction of ureteral and renal calculi: a pilot study. *J Endourol* 2008;22:1213–7.
- [26] Rajamahanty S, Grasso M. Flexible ureteroscopy update. Indications, instrumentation and technical advances. *Indian J Urol* 2008;24:532–7.
- [27] Aso Y, Ohta N, Nakano M, Ohtawara Y, Tajima A, Kawabe K. Treatment of staghorn calculi by fiberoptic transurethral nephrolithotripsy. *J Urol* 1990;144:17–9.
- [28] Cutajar CL. Norfloxacin prophylaxis for endoscopic urological surgery. *Br J Urol* 1992;69:421–4.
- [29] Lehman T, Bagley DH. Reverse lithotomy – A modified prone position for simultaneous nephroscopic and ureteroscopic procedures in women. *Urology* 1988;32:529–31.
- [30] Grasso M, Nord RG, Bagley DH. Prone split leg and flank roll positioning: Simultaneous antegrade and retrograde access to the upper urinary tract. *J Endourol* 1993;7:307–10.
- [31] Moraitis K, Philippou P, El-Husseiny T, Wazait H, Masood J, Buchholz N. Simultaneous antegrade/retrograde upper urinary tract access: Bart's modified lateral position for complex upper tract endourologic pathologic features. *Urol* 2012;79:287–92.
- [32] Undre S, Olsen S, Mustafa N, Patel A. 'Pass the ball!' Simultaneous flexible nephroscopy and retrograde intrarenal surgery for large residual upper pole staghorn stone. *J Endourol* 2004;18:844–7.
- [33] Albala DM, Assimos DG, Clayman RV, Denstedt JD, Grasso M, Gutierrez-Aceves J, et al. Lower pole I. A prospective randomized trial of extracorporeal shock wave lithotripsy and percutaneous nephrostolithotomy for lower pole nephrolithiasis-initial results. *J Urol* 2001;166:2072–80.
- [34] Pearle MS, Lingeman JE, Leveillee R, Kuo R, Preminger GM, Nadler RB, et al. Prospective, randomized trial comparing shock wave lithotripsy and ureteroscopy for lower pole caliceal calculi 1 cm or less. *J Urol* 2005;173:2005–9.