JAOA

Original contribution

Urolithiasis update: clinical experience with the Swiss LithoClast

JEFFREY SCHOCK, DO
ROBERT I. BARSKY, DO
JEROME R. PIETRAS, DO

This article describes the authors' first experience using the EMS Swiss LithoClast pneumatic lithotriptor in the management of middle and distal ureteral calculi. Also presented is a review of the literature comparing different modalities of intracorporeal lithotripsy. A retrospective analysis was performed on 11 patients treated with the Swiss LithoClast using the Circon ACMI MR6 Rigid Mini-ureteroscope (7 patients with distal calculi and 4 patients with midureteral calculi). The lithotriptor successfully fragmented 91% of the calculi, independent of stone composition. Complete failure of fragmentation was only encountered in one patient, and this was secondary to the lithotriptor's inherent ballistic force causing retrograde passage of the calculus. One patient had postoperative radiographic evidence of stone fragments along the ureteral stent. There was no intraoperative morbidity or long-term complications encountered with use of the pneumatic lithotriptor. Additionally, patients' overall satisfaction was 91% with respect to the procedure itself and relief of preoperative pain. The only significant postoperative complaint was ureteral stent discomfort in one patient.

The authors conclude that the EMS Swiss LithoClast pneumatic lithotriptor is a safe and effective tool in the management of middle and distal ureteral calculi. However, as noted with one patient, there is always a risk of stone push from the ballistic force of the lithotriptor.

(Key words: lithotripsy, ureteral calculi, Swiss LithoClast)

During the past 10 to 15 years, the management of urinary calculi has changed significantly. The natural progression, which originated with open surgical removal, moved to percutaneous nephrolithotomy, ureteroscopic extraction, and subsequently to extracorporeal shockwave lithotripsy (ESWL).[1] For the past several years, ESWL has maintained a stable presence within the urologic community with regard to urinary calculi. Known to be highly effective, ESWL has provided a completely noninvasive technique for the management of renal and ureteral calculi.[2]

Currently, with improvement in endourologic techniques, ureteroscopic intracorporeal lithotripsy has achieved recognition as an innovative and safe method of treating urinary calculi. Some of the current modalities for ureteroscopic lithotripsy include ultrasonic, electrohydraulic, and laser lithotripsy, as well as use of the new ballistic contact Swiss LithoClast system. Herein is a retrospective analysis of transurethral ureteroscopic pneumatic lithotripsy performed on 11 patients with urinary calculi.

At the time this article was written, Dr Schock was a chief resident in urology at the University of Medicine and Dentistry of New Jersey School of Osteopathic Medicine, Kennedy Memorial Hospitals–University Medical Center, Stratford, New Jersey, where Dr Barsky is an assistant professor of urology and Dr Pietras is program director and associate professor of urology.

Correspondence to Jeffrey Schock, DO, Tri-County Urologists, PC, 28711 West 8 Mile Rd, Suite B, Livonia, MI 48152.

E-mail: *galit7@aol.com*

Methods

A total of 11 patients with urinary calculi (5 men, 6 women) between the ages of 25 and 65 years (mean, 43.8 years) were treated with the Swiss LithoClast pneumatic lithotriptor (EMS Electro Medical Systems, Switzerland; *Figure 1*). The indications for intracorporeal stone fragmentation were persistent pain, obstructed lower pole segment, recurrent colic, and hydronephrosis. All patients were evaluated by use of urinalysis/culture, serum blood urea nitrogen, creatinine, serum electrolytes, and complete blood cell count. Radiologic evaluation varied within the patient pool but included plain abdominal radiography, intravenous urography, noncontrast spiral computerized axial tomography, and ultrasonography. A cystoscopic examination was performed on all patients before inserting the ureteroscope. Ureteroscopy was performed within the same hospital system using the MR6 Rigid Mini-ureteroscope (Circon ACMI, Santa Barbara, Calif). All cases used a 0.8-mm lithoclast probe via the working channel in the ureteroscope. Also, all patients received preoperative and postoperative ciprofloxacin therapy.

Patient satisfaction was assessed on a point system of 1 to 5. A score of 1 indicated complete satisfaction with the therapy, 2 indicated relative satisfaction with the overall outcome, 3 indicated relative indifference to the procedure, 4 indicated dissatisfaction with some aspects of the procedure as it related to the outcome, and 5 indicated complete dissatisfaction with the procedure and unwillingness to undergo the procedure again.

Results

The size of the calculi ranged from 3 mm to 10 mm (median size, 5 mm × 6 mm). All patients presented with unilateral ureteral calculi. Seven patients presented with distal ureteral calculi, and four patients had midureteral stones. Mild to moderate hydronephrosis was demonstrated in 36% of patients. Seven patients were treated on a same-day surgical basis,

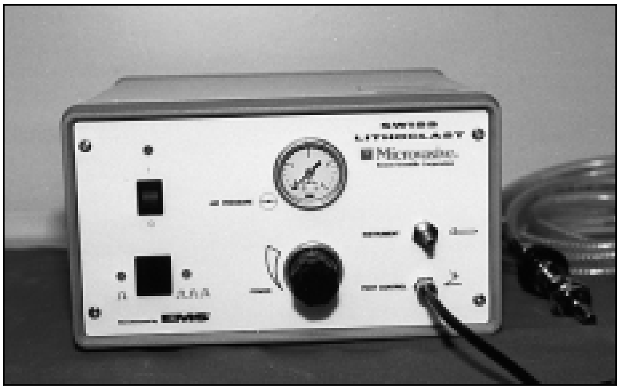


Figure 1. *The EMS Swiss LithoClast marketed by Microvasive/ Boston Scientific Corporation.* ▶

with the remainder either treated before or after extended hospital admission. Although stone analysis was not available at the time this article was written, 91% of ureteral calculi were radiopaque on plain radiography before surgical intervention. Satisfactory fragmentation was defined by subjective and objective visual confirmation of stone breakage with the pneumatic lithotriptor (*Figure 2*). Ninety-one percent of patients had successful fragmentation of ureteral calculi. Complete failure to fragment occurred in only one patient, in which case the ballistic force of the pneumatic lithotriptor pulse propelled the stone into a renal calyx via a proximally dilated ureter. Segura basket extraction of stone fragments was used in 54% of cases. Balloon dilation of the ureteral orifice was only deemed necessary in one patient in whom a strictured opening was identified. Additionally, lithotripsy with the Candela laser was initially attempted in one patient before using the Swiss LithoClast. Thirty-six percent of patients had a prior urinary stone history. All patients received ureteral stents, all but one of them getting double stents. The single remaining patient was treated with an overnight straight ureteral stent. The mean overall patient satisfaction score was 1.7, with 10 of the 11 patients (91%) indicating overall satisfaction with the procedure (*Figure 3*).

Comments

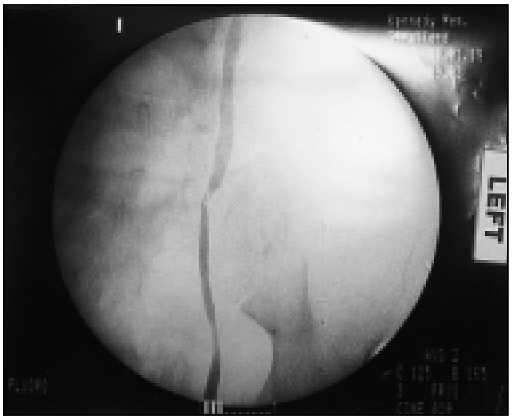
Extracorporeal shockwave lithotripsy has been a first-line treatment of renal and ureteral stones for at least the past 10 years. However, endourologic lithotripsy has found new use with the advent of ureteroscopic visualization. Although ureteroscopy provides well-established benefits in the management of urinary stones, it is nevertheless an invasive procedure with the inherent potential for complications. Minor complications include urinary tract infection and hematuria, while major complications include ureteral perforations and avulsions. Use of rigid and semi-rigid ureteroscopes and improvements in surgical technique have reduced the overall morbidity. The overall early and late complication rate is approximately 9% of the cases reported.[3] Ureteral perforation has been reported in 6% to 11% of cases involving rigid endoscopes and 2% to 5% involving the miniscope.[3] Even with the most sophisticated techniques, however, there are limitations with today's endourologic equipment. These limitations include the size of the working channel and the diameter of ureteroscope with respect to the ureteral orifice.

Currently, endourologic lithotripsy is performed in situ by use of a variety of different intracorporeal machines. Most commonly these include ultrasound, electrohydraulic shockwave, laser, and pneumatic lithotripsy (such as with the Swiss LithoClast). Choosing a particular technique requires taking into account both the characteristics of the stone to be treated and the potential adverse affects of the lithotripsy technique.[4] Each device has its advantages and limitations.

Electrohydraulic lithotripsy (EHL), the first intracorporeal option, was developed in the 1950s by Yutkin.[5] Electrohydraulic lithotripsy stone fragmentation is achieved via an electrical discharge through a fluid medium, causing a hydraulic shockwave. Ultrasonic lithotripsy relies on rapid vibration of the probe tip, which grinds the stone into fragments.

Holmium:YAG laser lithotripsy differs from prior generation lasers such as alexandrite, pulsed dye, and Q-switched lasers. Older lithotriptors had short pulse durations that deposited laser energy quickly, causing a high-energy vapor bubble. This bubble subsequently collapsed, thereby fragmenting calculi through a "photoacoustic effect."[6] In contrast, the holmium:YAG laser has a long pulse duration with a pear-shaped bubble. Fragmentation occurs through a "photothermal mechanism."[6] The net result of this modality is smaller fragmentation, and thereby less efficient/slower lithotripsy. However, the overriding major advantage is the holmium's ability to fragment all stone compositions.[6]

The Swiss LithoClast (a pneumatic lithotriptor), originally developed at the University Teaching Hospital in Lau-



◀ **Figure 2.** *Retrograde pyelogram of a 23-year-old man with acute onset of left costovertebral angle and lower abdominal tenderness. The ureteral filling defect corresponded to a mid-ureteral calculus. Subsequent pneumatic fragmentation was successful.*

sanne, Switzerland, is based on a jackhammer principle.[7] A projectile in the handpiece is propelled by compressed air through the probe. The compressed air originates from a small generator that is connected to a dry, clean air supply. The ballistic energy produced is conveyed to the probe base at a rate of 12 Hz.[8] Continued impaction of the probe tip against the stone results in stone breakage once the tensile forces of the calculus are overcome.[5] The metallic probe rods are available in five diameters: 0.8 mm, 1.0 mm (*Figure 4*), 1.6 mm, 2.0 mm, and 3.5 mm.

Piergiovanni and colleagues[4] studied the four modalities and their associated effects on the bladder and ureteral wall. Histologically, laser lithotripsy produced complete necrosis of ureteral epithelium with partial necrosis of the lamina propria and muscle as early as day 0. Electrohydraulic lithotripsy produced total abrasion of the epithelium with edema of the remaining layers by day 1. Denstedt[5] believes that EHL has the narrowest margin of safety of all forms of intracorporeal lithotripsy. Bhatta and coworkers[5] observed bladder perforations more consistently with EHL than with laser in rabbits. Furthermore, Piergiovanni and coworkers[4] demonstrated ultrasonic findings of total epithelial abrasion or epithelial detachment or both. Additionally, 250 direct shocks to the ureteral wall resulted in perforation. Despite this single exaggerated response to stress, Piergiovanni and others found the lithoclast to produce the least microscopic and macroscopic damage to the urothelium.[4,5] Meyer[9] histologically demonstrated absence of detectable urothelial damage with up to 20 direct lithotriptor shocks to the ureteral wall. Our experience with the pneumatic lithotriptor demonstrated no appreciable macroscopic ureteral wall damage and seems to be safer than the other modalities. This anecdotal experience is corroborated by most of the literature, including the studies by Denstedt, Meyer, Hofbauer, Preminger, and Piergiovanni.[5-10]

In a Duke University study, Teh and colleagues[8] provided a more standardized, scientific, and statistical evaluation of the Swiss LithoClast. The four different modalities of intracorporeal lithotripsy were tested on a standardized in vitro fragmentation method. The “fragmentation efficiency index” measured the lithotripsy time needed to “...reduce stone phantom weight particles less than 2 mm divided by the initial stone weight.” Teh and colleagues[8] demonstrated lower fragmentation indices (that is, better fragmentation efficiency) for the pneumatic lithotriptor. Histologic examinations, noted 2 weeks after treatment, revealed ureteral specimens without any significant urothelial injury.

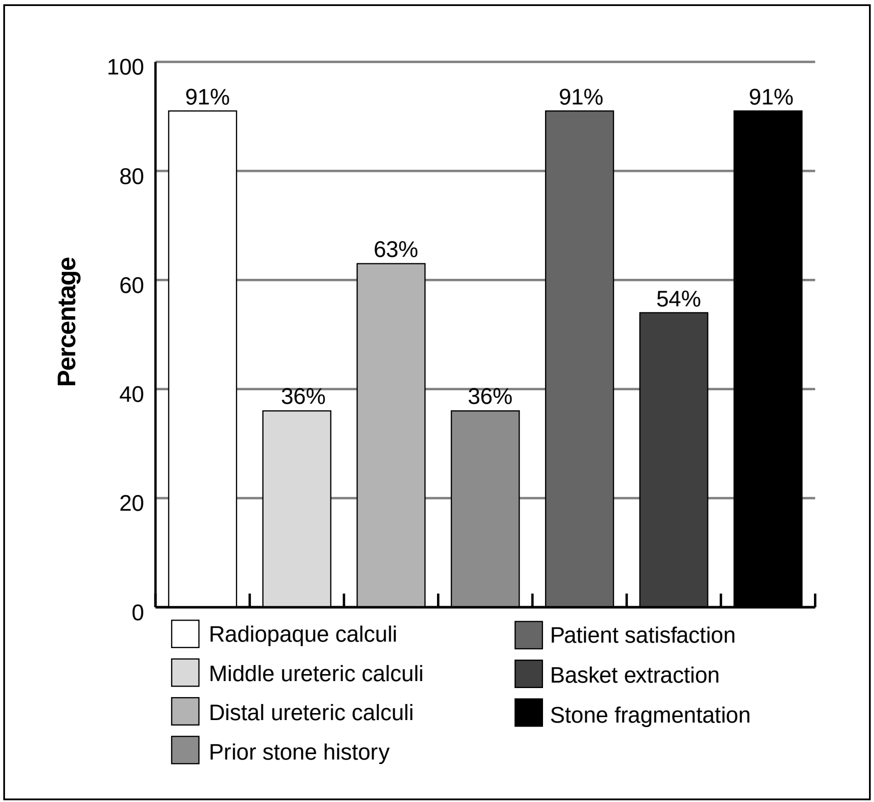


Figure 3. *Patient satisfaction with procedure using the EMS Swiss LithoClast pneumatic lithotriptor in the management of middle and distal ureteral calculi.*

Another critically important question in the determination of one modality over another is cost-effectiveness. Denstedt[5] demonstrated the comparison of initial capital outlay and the disposability cost (that is, recurring costs). Ultrasound, EHL, and lithoclast all cost between $20,000 and $30,000. The holmium-YAG lithotriptor is the most affordable unit and retails at approximately $60,000. Additionally, EHL probes are disposable and cost $200 each. The other three modalities all have reusable probes that can be easily maintained.

As demonstrated in this study, stone breakage with the Swiss LithoClast is highly effective. Pneumatic lithotripsy has the added benefit of better stone targeting and visualization than is possible with the laser. Rapid flashes of light emanating from the laser and visually obscuring protective eyewear may interfere with targeting.[11] Another advantage of pneumatic lithotripsy is the ability to crack harder stones, such as those composed of calcium monohydrate or cystine.[7,8,11] Naqvi and colleagues[11] found that pneumatic lithotripsy fragmented calcium oxalate monohydrate stones that proved resistant to laser lithotripsy. Dretler and others[3] showed that struvite, uric acid, and apatite stones are fragile from fragmentation compared with the much harder and black stones, such as brushite (calcium phosphate dehydrate) and calcium oxalate monohydrate. Our anecdotal perspective has dictated that stones too hard

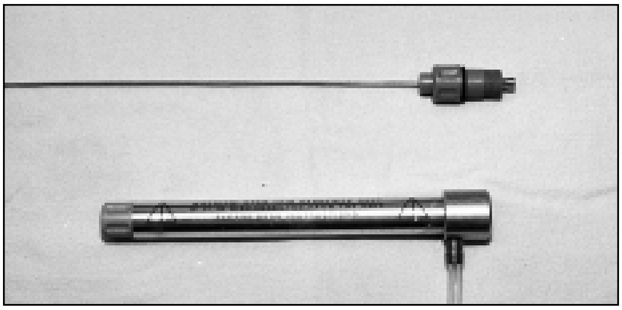


Figure 4. *Lithoclast handpiece and 1.0-mm probe (total handpiece length is 550 mm to 680 mm depending on actual probe length).* ▶

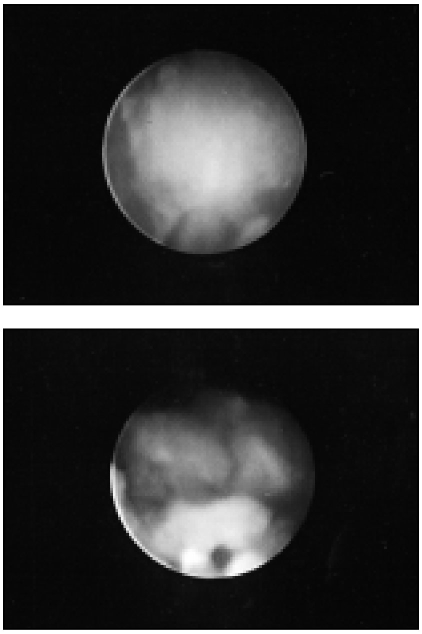


Figure 5. Top—*Lithoclast probe at 6 o'clock position in direct contact with ureteral calculus before fragmentation.* Bottom—*Postfragmentation remnants of ureteral calculus.*

for the Candela laser (that is, calcium monohydrate) are amenable to fragmentation by the Swiss LithoClast (provided a holmium laser is not available for use).

The choice of modality when deciding on intracorporeal lithotripsy is based on many factors, including ureteral level, stone type, the presence or absence of infection in a potentially obstructed system, available lithotriptor unit, and overall patient condition. Ultimately, the preference is the least invasive method of stone reduction with the fewest adverse effects. Other considerations include best patient tolerability from an analgesia standpoint and a long-term analysis of cost-to-benefit ratio with medical versus surgical management. However, practicality and managed care policies may often dictate that we use the most cost-effective management tool rather than take into account larger issues of cost-to-benefit ratios.

Our retrospective study demonstrated a 91% successful fractionation rate (*Figure 5*). There are many definitions of success, of course, but just as with Thuroff and colleagues,[12] we defined success for the purpose of this study to mean that a patient was free of both stone and symptoms. Most of the fragmented stones were radiopaque. These stones were thought to be primarily calcium oxalate monohydrate, based on their density on plain radiography and by endoscopic visual characterization. The stone analysis, which was not completed at the time of this article's writing, will be required to confirm or refute this assumption. Pneumatic lithotripsy has been reported to be successful in 88% to 100% of cases of ureteral stones.[2]

Overall, pneumatic lithotripsy's advantages include being user-friendly, being relatively less expensive than other modalities, causing negligible urothelial damage, and having high reliability for single-session stone fragmentation. The only appreciable disadvantages of this technique are the limitation of probe rigidity and the potential for proximal stone propulsion during treatment. This study demonstrated an inherent problem with proximal migration of ureteral calculi after ballistic impact. Denstedt and colleagues[7] also demonstrated the failure to trap ureteral calculi in large proximal dilated segments in two patients. With the advent of the new LithoVac suction device (EMS Electro Medical Systems, Switzerland) and the flexible lithoclast probes, further fragmentation failure may be prevented. From a cost, safety, and efficacy point of view, the Swiss LithoClast may be the best method of lithotripsy for middle and distal ureteral stones.

References

1. Wadhwa SN, Hemal AK, Sharma RK. Intracorporeal lithotripsy with the Swiss lithoclast. *Br J Urol* 1994;74:699-702.

2. Otkay B, Yavascaoglu I. Intracorporeal pneumatic lithotripsy for ureteral and vesical calculi. *Scand J Urol Nephrol* 1997;31:333-336.

3. Murthy PV, Gurunadha R. Ureteroscopic lithotripsy using mini-endoscope and Swiss lithoclast: experience in 147 cases. *J Endourol* 1997;11:327-330.

4. Piergiovanni M, Desgrandchamps F, Cochand-Priollet B, Janssen T, Colomer S, Teillac P, et al. Ureteral and bladder lesions after ballistic, ultrasonic, electrohydraulic, or laser lithotripsy. *J Endourol* 1994;8:293-299.

5. Denstedt JD. Intracorporeal lithotriptors. In: Smith A, Badlani GH, Bagley DH, et al, eds. *Smith's Textbook of Endourology.* St. Louis, Mo: Quality Medical Publishing; 1996: 47-63.

6. Teichman JM. The use of holmium:YAG laser in urology. *AUA Update Series* 2001;20: 154-158.

7. Denstedt JD, Parker ME, Singh RR. The Swiss lithoclast: a new device for intracorporeal lithotripsy. *J Urol* 1992;148:1088-1090.

8. Teh CL, Zhong P, Preminger GM. Laboratory and clinical assessment of pneumatically driven intracorporeal lithotripsy. *J Endourol* 1998;12:163-169.

9. Meyer WW. Basic studies in pneumatic lithotripsy with the Swiss lithoclast. *Japanese Journal of Endourology and ESWL* 1996;9:63-66.

10. Hofbauer J, Hobarth K, Marberger M. Lithoclast. New and inexpensive mode of intracorporeal lithotripsy. *J Endourol* 1992;6:429-431.

11. Naqvi SAA, Khaliq MN. Treatment of ureteric stones. Comparison of laser and pneumatic lithotripsy. *Br J Urol* 1994;74:694-698.

12. Thuroff S, Chaussy CG. First clinical experience and in situ treatment of ureteric stones using Lithostar Multiline lithotripter. *J Endourol* 1995;9:367-370.