Ureteroscopic Lithotripsy Using Swiss Lithoclast for Treatment of Ureteral Calculi: 12-Years Experience

Ureteroscopic lithotripsy using Swiss Lithoclast was performed in 411 cases from January 1996 to September 2007 in a single hospital. Medical records of 341 cases, in which Swiss Lithoclast was successfully applied, were available for this retrospective study. We used 9.5Fr and 10Fr Storz rigid ureteroscopes. A success was defined as being free of stone-related symptoms and residual stones larger than 2 mm. Sixty one stones were located in the upper ureter, 49 stones were in the mid ureter, and 231 stones were in the lower ureter. The overall success rate was 93.5%. The success rate of upper ureter stone (80.3%) was significantly lower compared with those of mid (93.8%) and lower (96.9%) ureter stones (P=0.001). The higher the calculi was located within the ureter, the more chance of upward migration there was (P<0.001). The success rate in male patients was lower than in female patients without a statistical significance (P=0.068). The success rate decreased as the size of the stone increased (P<0.001), and as the degree of hydronephrosis increased (P<0.001). Perforation rates were 4.9%, 4.1%, and 2.6% from upper to lower ureter stone group. Ureteroscopic lithotripsy using Swiss Lithoclast is a safe and useful treatment modality for ureteral calculi.

Key Words: Ureter; Calculi; Lithotripsy

INTRODUCTION

Urological treatment of urinary calculi has changed much in the past 20 yr. Various endourological treatment modalities are available for urinary calculi; ureteroscopic lithotripsy, shock wave lithotripsy (SWL), laparoscopic lithotomy, and percutaneous nephrolithotomy. Despite the liberal use of SWL, ureteroscopic lithotripsy is still the preferred treatment modality for managing ureteral calculi (1-3). Currently available semirigid ureteroscopes with a diameter of less than 7Fr and the flexible ureteroscopes can usually be passed up the ureter without ureteral dilation, thus, minimizing morbidity.

Advances in intraureteral lithotripters such as holmium: YAG laser or Freddy can yield better results. Compared with laser lithotripters, pneumatic lithotripter is old-fashioned and has some limitations of upward migration of stone fragments and the lack of fragmentation into small particles. Unfortunately, pneumatic lithotripter had been the only available tool of ureteroscopic lithotripsy in our hospital for 12 yr. Of course, it is well known that pneumatic lithotripter has some proven merits of safety and cost-effectiveness. We respectively reviewed our experience of ureteroscopic lithotripsy using Swiss Lithoclast.

MATERIALS AND METHODS

From January 1996 to September 2007, 411 ureteral calculi in 392 patients were treated in our institution with ureteroscopic lithotripsy using Swiss Lithoclast. Medical records of 341 cases in 326 patients were available for use in this retrospective study. Exclusion criteria were: radiolucent stone, stone size >2 cm, access failure, failure to apply Swiss Lithoclast. Fifteen patients had bilateral disease. Mean age of 326 patients was 48.1 yr (from 26 to 80).

The 341 cases were divided into three groups according to the stone location. Group 1 consisted of stones located above the pelvic brim (upper), group 2 consisted of stones located over the pelvic brim (mid) and group 3 consisted of stones located below the pelvic brim (lower). The number of cases in each group was 61 in group 1, 49 in group 2, and 231 in group 3. The characteristics of 341 cases are shown on Table 1. There were no significant differences of baseline characteristics including gender, age and stone diameter between the three groups.
The parameters used for comparison among the three groups were success rate, stent indwelling, intraoperative ureteral perforation. We also analyzed the success rates according to gender of the patients, stone size, and degree of hydronephrosis. Our entire equipments for ureteroscopic lithotripsy consisted of 9.5Fr, 10Fr Storz rigid ureteroscopes with 5Fr working channel, 5Fr foreign body forceps, stone basket, and Swiss Lithoclast with three probes (1.6, 1, and 0.8 mm). Routine biochemical analysis, blood count, urinalysis and culture of urine were performed preoperatively. Intravenous pyelogram or computed tomogram was taken to confirm the diagnosis and determine the location and the size of stones. Prophylactic antibiotics were injected intravenously in all patients.

The procedure was performed with the patients under either general or spinal anesthesia as decided by anesthesiologists. A safety guide wire was inserted into the ureter as a cystoscopic procedure. The ureteroscope was introduced via ureteral orifice with or without ureteral dilation. Ureteral dilation was performed using metal dilator or balloon dilator as necessary. Flow of irrigation was controlled by a valve attached to the ureteroscope and accelerated with squeezing pump as needed during operation. Lithoclast probes were passed through the working channel, placed in contact with the calculi, and stones were fragmented down to pieces smaller than 2 mm in diameter under video monitoring and foot control switch. Fragmented stones were removed out of the ureter as much as possible using basket or forceps.

A JJ stent (6 Fr 22, 24, 26 cm) was placed whenever decided necessary in cases of ureteral edema secondary to an impacted calculus, ureteral injury, and upward migration of stone fragments. A plain radiography of the kidneys, ureters and bladder (KUB) was performed 2 weeks after surgery to assess residual stone fragments. Success was defined as symptom-free and no evidence of residual stones larger than 2 mm in diameter, since stone particles less than 2 mm usually would pass the ureter spontaneously. The outcome of ureteroscopic lithotripsy was compared according to the location of calculi within ureter (Group 1, 2, 3). All variables were expressed as mean±standard deviation. The chi-square test, ANOVA and Fisher's exact test were used to compare parameters between the different groups. P<0.05 was considered statistically significant. Statistical analysis was performed with computer software (Statistical Package for the Social Science, version 12.0).

RESULTS

Success rate

The overall success rate at 2 weeks postoperative day was 93.5% (Table 2). The success rates were different according to the location of stone. The success rate of group 1 was 80.3%, and those of group 2 and 3 were 93.8% and 96.9%, respectively. The success rate of group 1 was significantly lower than other two groups (P=0.001). Success rates of group 2 and group 3 were not significantly different. The higher the calculi located within ureter, the more chance of upward migration there was (P<0.001). The success rate in male patients was lower than in female patients (91.6% vs. 96.9%), but there was no statistical significance (P=0.068, Table 3). The success rate decreased as the size of the stone increased (P<

Table 1. Baseline data of the subjects

|                  | Upper ureter (group 1) | Middle ureter (group 2) | Lower ureter (group 3) | Total | P value |
|------------------|------------------------|-------------------------|------------------------|-------|---------|
| No. of cases     | 61                     | 49                      | 231                    | 341   |         |
| Male             | 39                     | 27                      | 148                    | 214   | 0.488   |
| Female           | 22                     | 22                      | 83                     | 127   |         |
| Age (yr)         | 46.9±11.2               | 50.4±9.7                | 48.3±11.4              | 48.1±11.5 | 0.410   |
| Stone diameter (mm) | 10.9±4.5               | 8.7±4.3                 | 8.8±4.2                | 9.1±4.3 | 0.213   |

Table 2. Results and complications according to stone location

| Parameters                         | Upper (group 1) | Middle (group 2) | Lower (group 3) | Total | P value |
|------------------------------------|-----------------|------------------|-----------------|-------|---------|
| No. of cases                        | 61              | 49               | 231             | 341   |         |
| Success                            | 49 (80.3%)      | 46 (93.8%)       | 224 (96.9%)     | 319 (93.5%) | 0.001*  |
| Failure                            | 12 (19.7%)      | 3 (6.2%)         | 7 (3.1%)        | 22 (6.5%) |         |
| Migrated stones                    | 10 (16.4%)      | 4 (8.2%)         | 4 (1.7%)        | 18 (5.3%) | <0.001* |
| Perforation                        | 2 (3.3%)        | 0 (0%)           | 2 (0.9%)        | 4 (1.2%) | 0.148   |
| Stent indwelling                   | 41 (67.2%)      | 31 (63.3%)       | 140 (60.6%)     | 212 (62.2%) | 0.630   |
| Ureteral perforation               | 3 (4.9%)        | 2 (4.1%)         | 6 (2.6%)        | 11 (3.2%) | 0.422   |
| Lasting gross hematuria (>72 hr)   | 7 (11.4%)       | 5 (10.2%)        | 18 (7.8%)       | 30 (8.8%) | 0.453   |
| Pain requiring analgesics          | 30 (49.1%)      | 22 (44.9%)       | 96 (42.4%)      | 150 (44.0%) | 0.633   |

* group 2, group 3>group 1; † group 1> group 2> group 3.
Ureteral perforations were treated with stent indwelling for 2 to 8 weeks according to postoperative condition of the ureter. Stent was left in place for marked bleeding, impacted stone, residual stones, and included ureteral perforation, mucosal avulsion or marked edema. The indication of stent indwelling included ureteral perforation during lithotripsy. We failed to fragment the stones completely in four cases out of eleven ureteral perforations. Two failed patients were lost to follow-up, and the other 20 failed patients reached stone-free state with auxiliary SWL (15 cases) or medical expulsive therapy (3 cases) or repeated ureteroscopic lithotripsy (2 cases).

Complications (Table 2)

Ureteral perforation occurred in 11 patients (3.2%), and the incidence was 4.9% in group 1, 4.1% in group 2, and 2.6% in group 3 respectively. The highest incidence was noted in group 1, but the difference was not statistically significant. Ureteral perforations occurred in eight men and three women in group 1, but the difference was not statistically significant. Ureteral perforations occurred in eight men and three women in group 1, but the difference was not statistically significant. Ureteral perforation during lithotripsy is rare but significant. In this study, ureteral perforation requiring surgical correction occurred in 0.65% (10). USL could be a safe and effective treatment option for ureteral stones; however, other therapeutic modalities should be considered in patients with currently identified risk factors associated with treatment failure following a single USL procedure.

Holmium:YAG laser lithotripsy differs from prior generation lasers such as alexandrite, pulsed dye, and Q-switched lasers. Older lithotripters 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’ (11). In contrast, the holmium:YAG laser has long pulse duration with a pear-shaped bubble and fragmentation occurs through a ‘photothermal mechanism’ (11). The net result of this modality is smaller fragmentation, and thereby less efficient/slower lithotripsy.

Table 4. Success rates according to stone size and location

| Location  | <5 mm (HN) | 5-10 mm (HN) | >10 mm (HN) | P value |
|-----------|------------|--------------|-------------|---------|
| Upper     | 2/2 (100.0%) | 3/8 (37.5%)  | 5/18 (27.8%) | 0.1264  |
| Middle    | 9/11 (81.8%) | 26/29 (89.7%)| 13/14 (92.9%)| 0.2507  |
| Lower     | 55/72 (76.4%)| 138/141 (97.9%) | 30/33 (90.9%)| 0.0981  |
| Total     | 66/86 (76.5%)| 198/206 (96.1%)| 55/87 (62.1%)| 0.0005  |

0.001, Table 4, and as the degree of hydronephrosis increased (P=0.03, Table 5). Residual stones larger than 2 mm were noted in 22 cases at 2 weeks after surgery. Eighteen cases of failure were due to upward migration of stones during lithotripsy and the other four cases of failure was associated with incidental ureteral perforation during lithotripsy. We failed to fragment the stones completely in four cases out of eleven ureteral perforations. Two failed patients were lost to follow-up, and the other 20 failed patients reached stone-free state with auxiliary SWL (15 cases) or medical expulsive therapy (3 cases) or repeated ureteroscopic lithotripsy (2 cases).

Stent indwelling

The rate of stent indwelling was 67.2% (41/61) in group 1, 65.3% (29/45) in group 2, and 63.3% (59/94) in group 3 respectively. The overall rate of stent indwelling was 62.2% (212/341) (Table 2). The indication of stent indwelling included ureteral perforation, mucosal avulsion or marked edema, marked bleeding, impacted stone, residual stones, and the surgeon's preference. Ureteral stent was left in place for 2 to 8 weeks according to postoperative condition of the ureter. Ureteral perforations were treated with stent indwelling for 4 to 8 weeks without open surgery.

Table 5. Success rates according to degree of hydronephrosis (HN) and stone location

| Location | Mild HN | Moderate HN | Severe HN | P value |
|----------|---------|-------------|-----------|---------|
| Upper    | 8/12 (66.7%) | 7/10 (70.0%) | 5/6 (83.3%) | 0.4296  |
| Middle   | 14/17 (82.4%) | 11/12 (91.7%) | 7/5 (85.7%) | 0.3606  |
| Lower    | 26/28 (92.9%) | 9/10 (90.0%) | 4/5 (80.0%) | 0.1747  |
| Total    | 58/75 (77.3%) | 37/42 (88.1%) | 26/31 (83.9%) | 0.0349  |

DISCUSSION

Means of ureteroscopic lithotripsy include ultrasound, electrohydraulic, pneumatic, and laser. These instruments are passed through the working channel of the ureteroscope to fragment stones into extractable pieces. In choosing a specific lithotripter operators should take into account not only the characteristics of the stone but also the potential adverse events of the specific lithotripsy technique (4). Every device has its advantages and limitations. Electrohydraulic lithotripsy (EHL), the first intracorporeal option, was developed in the 1950s (5). Stone fragmentation is achieved via an electrical discharge through a fluid medium, causing a hydraulic shockwave. Although some authors reported fragment rates reaching up to 100% related to EHL, tissue trauma were the main problem (6-9). Stone free rates of EHL for ureteral calculi ranges from 85.3% to 100% and complication rates ranges from below 10% to 45%. Compared with other ureteroscopic lithotripters, EHL has more complications including ureteral perforation.

Ultrasonic lithotripsy (USL) relies on rapid vibration of the probe tip, which grinds the stone into fragments. USL requires large-diameter instruments with a straight operating channel; therefore preoperative dilation of the intramural ureter in necessary. This process prolongs the time required for the procedure and increases the amount of ionizing radiation to the patient. The reported stone-free rate following a single treatment with USL ranges from 73.3% in a large scale study (10) to 89.4% in a small study (8). According to a large scale study, ureteral perforation requiring surgical correction occurred in 0.65% (10). USL could be a safe and effective treatment option for ureteral stones; however, other therapeutic strategies should also be considered in patients with currently identified risk factors associated with treatment failure following a single USL procedure.

Holmium:YAG laser lithotripsy differs from prior generation lasers such as alexandrite, pulsed dye, and Q-switched lasers. Older lithotripters 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’ (11). In contrast, the holmium:YAG laser has long pulse duration with a pear-shaped bubble and fragmentation occurs through a ‘photothermal mechanism’ (11).
Swiss Lithoclast for Ureteral Calculi

Effective on every stone composition including calcium oxalate of safety and cost-effectiveness. Pneumatic lithotripter is very It is well established that pneumatic lithotripter has merits other treatment modalities including holmium:YAG laser.

The rate of ureteral stricture was reported as 0.5% (24). The rate of ureteral perforation (3.2%) and stricture formation due to upward migration. The use of a suction device (Lithovac) was 5.28%, and 16.4% of upper ureter stone cases failed due to upward migration. The overall rate of stone migration in this study was 5.28%, and 16.4% of upper ureter stone cases failed due to upward migration. The use of a suction device (Lithovac) in conjunction with the Lithoclast or of occlusion devices (basket, occlusion balloon catheter, Stone Cone) or occlusion material (lidocaine jelly) decreases the migration rate (20-22). We used a basket only in some indicated cases of upper ureter stone during pneumatic lithotripsy. We did not have a flexible ureteroscope, so we used SWL for migrated stones left in renal collecting system. The reported rate of ureteral perforation and avulsion during ureteroscope is 0-4% (23), and the rate of ureteral stricture was reported as 0.5% (24). The rates of ureteral perforation (3.2%) and stricture formation (0%) in this study are similar to or lower than these values.

Ureteral stenting after ureteroscopic lithotripsy is a common practice to prevent postoperative complications such as ureteral obstruction. Some investigator noted that uncomplicated ureteroscopy can be performed without routine stenting with minimal patient discomfort and a low incidence of postoperative complications (25, 26). Denstedt et al. reported that patients, in whom a stent was not inserted, were not at increased risk for complications and postoperative symptoms including flank pain after ureteroscopy compared with those with a stent, and ureteral stenting after uncomplicated ureteroscopic stone fragmentation was no longer absolutely necessary in all cases (27). We placed ureteral stent even when ureteral injury was not remarkable to prevent postoperative complications such as ureteral stricture. We believe that the liberal use of stent in this study could lead a good result against ureteral stricture.

In conclusion, pneumatic lithotripsy with Swiss Lithoclast is an effective and safe treatment modality for ureter stones. Its efficacy is reduced in case of large sized upper ureter stones with marked hydroureter because of higher chance of stone fragment migration during lithotripsy.

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