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ORIGINAL PAPER

Transurethral cystolithotripsy with a novel special endoscope

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Abstract To evaluate the safety and efficiency of the Aihua (AH)-1 stone removal system (SRS) to treat bladder stones. Thirty five patients with of bladder stones >2 cm and with benign prostatic hyperplasia were treated by transurethral cystolithotripsy with the SRS and TURP. The results in these patients were compared with 14 patients treated with current devices. In the SRS group, 26 patients had a single stone. Average stone size was 3.34 ± 1.03 cm, total operating time was 55.12 ± 19.95 min, and stone removal time was 23.30 ± 17.08 min. In the control group, 12 patients had a single stone. The average stone size was 2.46 ± 0.45 cm (larger stone size in SRS group, $P < 0.05$), total operating time was 79.85 ± 24.63 min (shorter operating time in SRS group, $P < 0.05$) and stone removal time was 43.28 ± 24.18 min the control group (shorter removal time in SRS group, $P < 0.05$). Mean stone size was 2.37 ± 1.18 cm and mean time to remove one stone was 12.57 ± 12.99 min in the SRS group. Mean stone size was 2.40 ± 0.48 cm (no significant difference between groups, $P > 0.05$) and mean time to remove one stone was 33.23 ± 25.26 min in the control group (shorter time in the SRA group, $P < 0.001$). No significant complication was found in the SRS group. This study suggests that multiple functions of SRS can be expected in transurethral cystolithotripsy. It can be used to fix stones during lithotripsy, and automatically collect stones and extract more stones through the sheath at one time during lithoextraction, which can reduce surgical time and damage to the bladder and urethra. This surgical procedure appears to be safe and efficient, and operating indications for transurethral cystolithotripsy could be expanded with this surgical procedure.

Keywords Bladder stone · Transurethral cystolithotripsy · Endoscope · AH-1 stone removal system

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Introduction

The management of bladder calculi has been developed in the recent decade, with the result that multiple management modalities are available [1–9]. Transurethral approaches for bladder calculi or cystolitholapaxy is probably the most common way to manage cystolithiasis, and especially appropriate if there are associated bladder outlet pathologies [9–14]. But current transurethral cystolithotripsy still has several deficiencies, such as the used devices can't be used to fix stone, continuously irrigate and efficaciously extract fragments in cystolitholapaxy. The surgical difficulty will be increased when the stones are >2 cm. Stone removal system (SRS) invented by us, which is primarily used to crush and evacuate bladder stone, is an special endoscope with multiple functions such as fixing stone, crushing stone, automatically gathering stone, extracting stone, washing out stone, and continuous irrigation in cystolithotripsy. Unusually, the minimal invasive device can be used to automatically collect stone and more fragments can be extracted at one time.

In the present study, the safety and efficiency of transurethral cystolithotripsy with SRS to treat bladder stone >2 cm were retrospectively evaluated after compared with current devices.

Patients and methods

Between January 2008 and January 2012, 35 cases of bladder stone with benign prostatic hyperplasia (BPH) were treated by transurethral cystolithotripsy with SRS and TURP in our department, after informed consents were obtained from patients, and they were separated as SRS group. These were compared with retrospective cohort of 14 cases of bladder stone with BPH treated by transurethral cystolithotripsy with current devices and TURP as control group. Follow-up was performed in 3 month postoperatively. Patient age was 48–97 years, with a mean age of 76.94 years. Stone size and operating time were respectively compared between the two groups.

All patients were evaluated by physical examination, International Prostate Symptom Score, complete blood count, blood biochemistry, serum prostate-specific antigen level, ultrasonography, and plain abdominal radiography. Prostate volume was measured by ultrasonography or CT scan, and stone size was measured by plain abdominal radiography. The used irrigation fluid was saline in cystolithotripsy and mannitol in TURP as usual.

Surgical instruments and techniques

These procedures were performed in the lithotomy position under spinal anesthesia. Holmium laser was used to perform lithotripsy, and the power setting used of holmium laser was 2.6–3.5 J and 2.0–2.5 Hz. Surgical procedures in the two groups were as follows:

SRS group

26F SRS is composed by illuminant and imaging component, continuous-flow component, a jaw to grasp and extract stone, lithotripsy tube, handle, and sheath (Photo 1). Inner diameter of the sheath is 8.2 mm and it can be connected with Ellik evacuator. Sphere >60 mm in diameter can be fixed with jaw by occlusive force and downward pressure, sphere <15 mm can be grasped directly, and sphere <8 mm can be extracted through sheath. The lithotripsy tube is 1.4 mm in inner diameter, by which, holmium laser fiber or pneumatic lithotripter probe can be transited to perform lithotripsy. The entire device is usually attached to a video camera to provide vision for the surgeon.

During the surgical procedure, first SRS was inserted into bladder to search stone. Then, stone was graspbed and fixed using jaw, and lithotripsy was performed with holmium laser through lithotripsy tube (Photo 2). Fragments could be extracted using jaw through sheath synchronously (Photo 3). If there were more smaller residual fragments, Ellik evacuator could be connected with sheath to wash out them. Finally, resectoscope was inserted in urethra to perform TURP.

The endoscope was designed by Aihua Li, M.D., and manufactured by Hangzhou Tonglu Shikonghou Medical Instrument Co., Ltd.

Control group

A 26F Storz continuous-flow resectoscope was used in the procedure. After resectoscope was inserted in urethra, stones were fixed with the sheath. Then, lithotripsy was performed by an 8F Storz ureteroscope using holmium laser through resectoscope sheath. Fragments were washed out with Ellik evacuator and larger residual fragments could be extracted using wire loop of resectoscope through urethra. TURP was performed immediately after above procedure.

The surgery in the two groups was performed by one surgeon.

Statistical analysis

The differences of measurement data were compared using an unpaired t test and Chi-square test. Difference was considered significant at a P value <0.05. The reported values are the mean $\pm$ SD.

Results

The characteristics and operative parameters in the two groups are shown in Tables 1, 2, 3.

Nine patients (25.71 %) were with multiple stones and a cumulative total of all stones was seventy in SRS group. Two patients (14.29 %) were with multiple stones and the total stone was seventeen in control group.

In control group, 3 cases (21.43 %) were converted to an open procedure, in which, 1 case for bladder perforation due to mucosal damage and 2 cases for excessive residual fragments to be removed. Furthermore, urethral stricture was developed in other 2 cases in 3 month postoperatively. In SRS group, TURP was performed first in three patients

Table 1 Characteristics of patients

	N	Age	Stone size (cm)	Prostate volume (ml)
SRS group	35	78.09 ± 5.17	3.30 ± 1.09 (2.0–6.4)	60.25 ± 39.58
Control group	14	74.07 ± 12.88	2.54 ± 0.46 (2.0–3.0)	52.16 ± 43.80

SRS group was compared with control group, the difference of stone size ($P < 0.05$) was statistically significant but the difference of age and prostate volume was not

Table 2 Operating time of patients with single stone

	SRS group	Control group
Case	26	12
Stone size (cm)	3.34 ± 1.03	2.46 ± 0.45
Total operating time (min)	55.12 ± 19.95	79.85 ± 24.63
TURP time (min)	31.82 ± 9.49	36.57 ± 11.82
Stone removal time (min)	23.30 ± 17.08	43.28 ± 24.18

Compared between the two groups, the difference of stone size ($P < 0.05$), total operating time ($P < 0.05$) and stone removal time ($P < 0.05$) was statistically significant

Table 3 Mean time to remove one stone

	SRS group	Control group
Case	35	14
Total stone	70	17
Mean stone number	2.18	1.21
Biggest stone (cm)	6.4	3
Mean stone size (cm)	2.37 ± 1.18	2.40 ± 0.48
Mean time to remove one stone (min)	12.57 ± 12.99	33.23 ± 25.26

Compared between the two groups, the difference of mean time to remove one stone ($P < 0.001$) was statistically significant but the difference of mean stone size was not

for urethral stricture or larger median lobe of prostate. No significant complication was found in the surgical procedure. However, a patient with multiple stones who was 97 years old, with a largest stone in 5.8 cm, second lager stone in 2.2 cm and other 15 stones <2 cm, undergone a second endoscopic procedure at 14 day postoperatively for surgical safety. To other 2 case with severe urethral stricture, urethral dilatation was performed first, and then TURP was performed with a 24F Storz resectoscope, cystolithotripsy was successfully accomplished finally. But surgical vision was too blurred to perform due to bleeding from resected fossa of prostate.

Discussion

Variety of treatment modalities have been mentioned in literature regarding removal of bladder stone—open surgical, lithotripsy, percutaneous, and transurethral [1–8]. But the most commonly used contemporary treatment for bladder stones is transurethral cystolithotripsy [8–14]. It can be performed using lithotriptoscope, ureteroscope, nephroscope, cystoscope and resectoscope. But until now, three major deficiencies still can't be perfectly resolved in the procedures. First, bladder stone is easily rolling within bladder for the large cavity, which makes fragmentation more difficult sometimes, especially to larger stone; Second, excessive fragments are produced after large bladder stone is crushed, but men urethra is slender and curl so that lithoextraction is much hard; Finally, some current devices can't be continuously irrigated so that surgical vision is poor in the procedure, which makes bladder mucosa easily injured. It even leads to bladder perforation, especially when bladder is filled by irrigating solution.

Nephroscope has distinct advantage over other current endoscopes in transurethral cystolithotripsy as it has a wider lumen, which facilitates easy removal of the stone fragments. But current forceps only can be used to extract smaller stone, remove one fragment at one time and can't be used to fix stone during lithotripsy [9]. Meanwhile, repeated lithoextraction through urethra would be damage to urothelium.

Resectoscope sheath could be used to fix stone and then lithotripsy is performed through the sheath by ureteroscope. Resectoscope could be connected with Ellik evacuator and smaller fragments can be washed out through working tunnel. In the surgery, larger fragments could be extracted using wire loop through urethra but the electrode sheathed is made by wire so that it is easily damaged and the fixer to wire loop would be damaged after reiterative application in such way. Furthermore, the efficiency to fix stone is obviously not good as the jaw of SRS and will be sharply decreased when stone size is >2 cm. Therefore, this method is more applicable to bladder stone <2 cm.

In the study, the designed multiple functions of SRS had been shown in cystolitholapaxy. The jaw, like a ring in longitudinal, is located at the front of objective lens and open downward, and the central part still is a circular cavity when it is closed. The lithotripsy tube is located at the lower edge of objective lens, which facilitates fragmentation in direct vision. Two jaw pieces are frame-shaped, which is favorable to grasp and fix stone. Two little

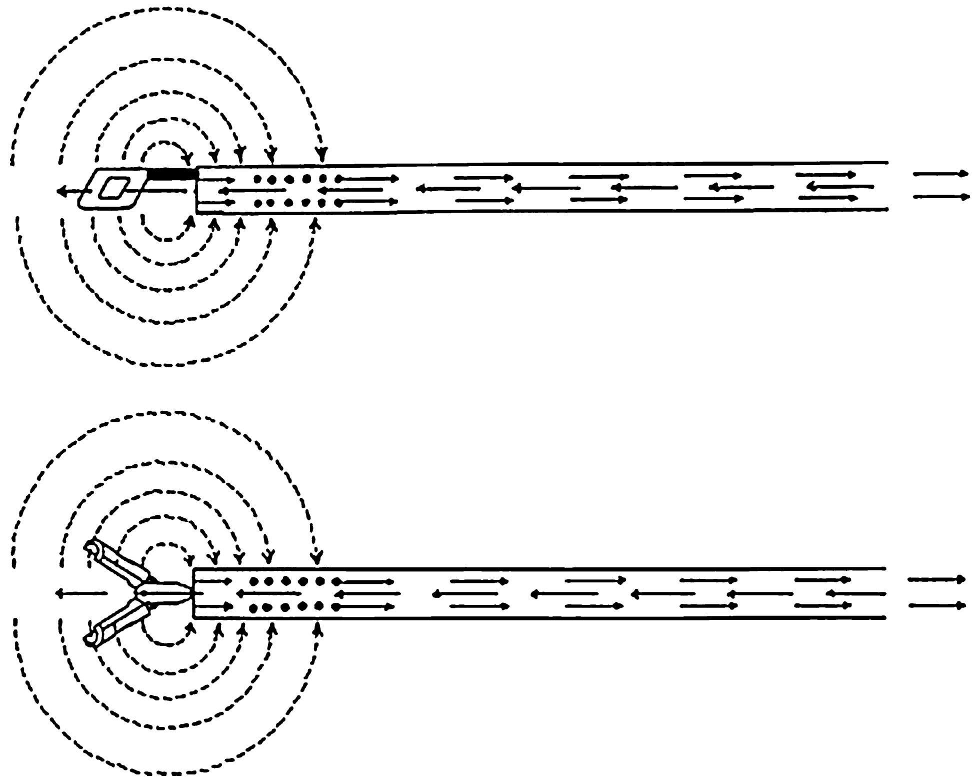

Fig. 1 The principle of swing flow

bars are installed at the far end of jaw so that it can be used to extract stone fragments through sheath as a trawler and more fragments can be extracted at one time. On other hand, Ellik evacuator can be connected with sheath to wash out smaller fragments. The principle of swing flow is applied in design, which makes the device to collect fragments automatically (Fig. 1). In stone fragmentation, holmium laser fiber or pneumatic lithotripter probe can be transited through lithotripsy tube to crush stones.

In the surgical procedure, stones are fixed with jaw and then are crushed, which makes fragmentation more effective for that stones are no longer rolling in bladder. Fragments <8 mm can be extracted with jaw through sheath or washed out using Ellik evacuator. As a result, the sheath doesn't have to be repeatedly inserted through urethra and which will effectively reduce damage to urethral mucosa. In some instances, larger fragments could be extracted through urethra, but the management will bring more injury to urethra so that it shouldn't be used repeatedly.

In the surgical procedure, to avoid injury to urethra and bladder, after sheath of SRS is inserted, working component should be inserted into bladder through the sheath always in direct vision. Frequent drainage of the bladder or low-pressure continuous irrigation during the procedure is important to prevent bladder rupture. Keeping continuous irrigation in procedure is of great benefit to keeping surgical vision clear and preventing bladder damage. For advanced aged and high risk patient, or too many, large and hard stones, surgery could be performed in phases. We prefer to remove bladder stone first in surgery of SRS combined with TURP, because surgical vision may not be as clear after TURP, for associated hematuria from the resected fossa. However, if median lobe of prostate is too large to perform fragmentation, the median lobe could be resected first in order to facilitate operation.

Transurethral lithotripsy can be safely combined with TURP, with one study showing slightly higher complication rate from hematuria when compared with TURP alone [11–14]. Combined TURP and percutaneous cystolithotripsy is safer, more effective, and much faster alternative to combined TURP and transurethral cystolithotripsy in patients with large bladder stones and BPH [2–4, 15]. In principle, SRS also can be used in percutaneous procedure. But in the study, the largest stone in SRS group was 6.40 cm and it was successfully crushed and extracted through urethra using the device so that bladder puncture has been satisfyingly avoided.

Conclusions

Our study shows that multiple functions such as fixing stone, crushing stone, automatically gathering stone, extracting stone, washing out stone and continuous irrigation can be expected when SRS is applied in transurethral cystolithotripsy. Especially, it can be used to fix stones during lithotripsy, and automatically collect stone and extract more stones through sheath at one time during lithoextraction, which can effectively reduce stone removal time and surgical damage to bladder and urethra. This minimally invasive endoscopic procedure appears to be safe and efficient, which could expand the operating indication on transurethral cystolithotripsy. Additional randomized trials comparing other endoscopes are warranted to delineate the best device to manage bladder stone.

Conflict of interest No competing financial interests exist.

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