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Original article

Comparison of pneumatic and Holmium laser ureteroscopic lithotripsy for upper third ureteral stones

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ABSTRACT

Objective: To evaluate the outcomes of ureteroscopic lithotripsy with pneumatic lithotripter and Holium:Yttrium-Aluminum-Garnet (Ho:YAG) laser in the management of upper third ureteral stones.
Materials and methods: Patients who underwent ureteroscopic lithotripsy with pneumatic lithotripter or Ho:YAG laser for upper third ureteral stones were retrospectively reviewed. Patients with urinary tract infection, radiolucent stones, loss of follow-up, concurrent middle or lower third ureteral stones or acute renal failure were excluded. Patient age, stone size and burden (based on KUB or computerized tomography), stone upward migration, double J stent insertion rate, stone free rate and secondary intervention rate for residual stones were compared in both groups.
Results: There were 158 patients with 178 upper third ureteral stones (135 in pneumatic lithotripsy group and 43 in Ho:YAG laser lithotripsy group) meeting the study criteria. Patients' age, gender, stone laterality, stone size and burden were similar in both groups. The Ho:YAG laser lithotripsy group had better stone free rate, less double J stent insertion rate and less secondary intervention rate as compared with pneumatic lithotripsy (53.4% vs. 40.1%; 72.1% vs. 91.9%; 25% vs. 48.5% respectively, all $p < 0.05$). In patients with stones larger than 10 mm, Ho:YAG laser lithotripsy had significantly lower upward migration rate, lower double J stent insertion rate, higher stone free rate and less secondary intervention rate.
Conclusions: Ho:YAG laser lithotripsy is superior to pneumatic lithotripsy in the management of upper third ureteral stones in terms of double J stent insertion rate, stone free rate and secondary intervention rate for stones of all sizes. For stones larger than 10 mm, laser lithotripsy results in less stone upward migration.
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1. Introduction

The treatment of upper third ureteral stone is common in daily urological practice. Extracorporeal shock wave lithotripsy, ureteroscopic lithotripsy, and percutaneous nephrolithotomy are the recommended therapeutic modalities for upper third ureteral stones refractory to medical expulsive therapy. The outcomes vary according to the size of the stone, degree of obstruction, duration of the symptoms, and the experience of the surgeons. Ureteroscopic lithotripsy with ultrasonic, electrohydraulic, pneumatic, and laser lithotripters has evolved steadily in the past 20 years, resulting in decreased morbidity and better outcomes.[1–3] Pneumatic lithotripsy uses vibrating mechanical force to break the stone. It may have a lower risk of ureteral perforation when compared with laser lithotripsy, but it is associated with a higher rate of stone pushback into the renal pelvis.[4] A previous study revealed the stone-free rate varied according to stone size.[2] We therefore compared these two modalities for the treatment of upper third ureteral stones, and focused on the effect of stone size on treatment outcomes.

2. Materials and methods

Patients who underwent ureteroscopic lithotripsy for upper third ureteral stone by pneumatic lithotripter or holium:yttrium–aluminum-garnet (Ho:YAG) laser between 2012 and 2013 were retrospectively reviewed. Patients with urinary tract infection, radiolucent stone, loss of follow-up, concurrent middle or lower third ureteral stone, or acute renal failure were excluded

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Figure 1. Area of the stone calculated by the imaging system.

from the study. The stone size and burden were evaluated by computerized tomography and/or plain radiography of kidney–ureter–bladder. The size was defined as the longest diameter of the stone. The sum of the stone sizes was used if there were more than one stone. The stone burden was defined as the area of the stone calculated by our imaging system after the stone was delineated (Figure 1). Follow-up kidney–ureter–bladder or computerized tomography was performed 1 month after ureteroscopic lithotripsy. Stone upward migration was defined as a stone fragment > 3 mm pushed back into the kidney visible on radiography. The stone-free rate was defined as no residual stones > 3 mm within the urinary tract 1 month postoperatively.

The patients' age, sex, stone size, stone burden, upward migration, stone-free rate, double J insertion rate, secondary intervention (extracorporeal shock wave or ureteroscopic lithotripsy) rate for residual stones, and major complications (Clavien Grades III–V) were recorded.

Table 1
Comparison of patient demographics, stone characteristics, and outcomes between the pneumatic and laser lithotripsy groups.

Characteristics	Pneumatic lithotripsy	Laser lithotripsy	*p*
Patient no.	118	40	
Treatment no.	135	43	
Sex: male/female	69/49	30/10	
Age (y)	53.5 ± 11.5	52.9 ± 9.4	0.381
Stone laterality left/right	70/65	23/20	
Stone size (mm)	13.8 ± 7.2	14.2 ± 11.2	0.443
Stone burden (mm^2)[a]	80 ± 32.3	81.4 ± 70.3	0.452
Ureteral stone multiplicity (%)	15.6	23.3	0.123
Upward migration (%)	43.7	34.9	0.091
Double J insertion (%)	91.9	72.1	<0.001
Stone-free rate (%)	40.1	53.4	0.042
Secondary intervention rate (%)	48.5	25	0.008
≥ Clavien Grade III complication	0	0	

[a] Stone burden was defined as the stone area calculated by the imaging system.

3. Operative technique

A semirigid 6/7.5-F ureteroscope (Wolf, Knittlingen, Germany) was used for all procedures.

Settings for Ho:YAG laser (Wavelight, AURIGA, Erlangen, Germany) lithotripsy with a 600-μm fiber were: energy 1.2–1.6 J and frequency 8–12 Hz. Settings for pneumatic lithotripsy (Swiss LithoClastMaster and LithoClast2, EMS, Nyon, Switzerland) were: energy 4 bar and frequency 5 Hz. The patient was placed in reverse Trendelenburg position and decreasing water pressure by lowering the water bottle. After lithotripsy, larger stone fragments were removed and placed in a basket and the smaller ones were left for spontaneous passage. At the end of the procedure, a 6-Fr double J stent insertion was considered, depending on the burden of residual stones, ureteral injury, bleeding, and granulation formation at the stone impact site. Perioperative intravenous broad spectrum antibiotics were given to all patients.

4. Statistical analyses

The Student *t* test and Chi-square test were used for comparison between pneumatic and laser lithotripsy groups. A p value < 0.05 was regarded as statistically significant.

5. Results

A total of 158 patients (118 patients in pneumatic lithotripsy group and 40 patients in Ho:YAG laser group) underwent 178 procedures (135 pneumatic lithotripsies and 43 Ho:YAG laser lithotripsies). The mean age of patients undergoing pneumatic and Ho:YAG laser lithotripsy was 53.5 years (22–92 years) and 52.9 years (21–69 years), respectively. The stone size and burden in both groups were not significantly different. For all stone sizes, the rate of double J insertion was lower in the laser than in the pneumatic group (72.1% vs. 91.9%, $p < 0.001$). The stone-free rate was higher in the laser group (53.4% vs. 40.1%, $p = 0.041$). There were fewer secondary interventions for residual stones in the laser group (48.5% vs. 25.0%, $p = 0.008$; Table 1).

For stones > 10 mm, the rates of upward migration, double J insertion, and secondary intervention were significantly lower in

Table 2
Outcomes in patients with stones ≥ 10 mm.

Characteristics	Pneumatic lithotripsy	Laser lithotripsy	*p*
Treatment no.	83	27	
Stone size (mm)	18.2 ± 13.6	18.1 ± 12.7	0.483
Stone burden (mm^2)	110.4 ± 74.3	114 ± 61.2	0.420
Upward migration (%)	62.7	37	0.011
Double J insertion (%)	96.4	80.8%	< 0.001
Stone-free rate (%)	18.1	48.1	< 0.001
Secondary intervention rate (%)	69.5	37	0.001

Table 3
Outcomes in patients with stones < 10 mm.

Characteristics	Pneumatic lithotripsy	Laser lithotripsy	*p*
Treatment no.	52	17	
Stone size (mm)	6.92 ± 1.92	7.6 ± 1.2	0.072
Stone burden (mm^2)	25.7 ± 12.2	32 ± 13.9	0.034
Upward migration (%)	13.5	29.4	0.061
Double J insertion (%)	84.6	58.8	0.011
Stone-free rate (%)	76.9	64.7	0.164
Secondary intervention rate (%)	15.3	11.7	0.352

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