Original Article

Euromediterranean Biomedical Journal
for young doctors
(formerly: Capsula Eburnea)

PNEUMATIC LITHOTRIPSY VERSUS HOLMIUM:YAG LASER LITHOTRIPSY IN THE MANAGEMENT OF URETERAL STONES

Sebastiano Cimino [1], Vincenzo Favilla [1],Giorgio I. Russo [1], Alberto Saita [1], Giuseppe Sortino [1], Anna Scavuzzo [1], Tommaso Castelli [1], Massimo Madonia [2], Giuseppe Morgia [1]

SUMMARY

Background: Pneumatic lithotripsy (PL) and Holmium:YAG laser lithotripsy (LL) are two valid mini-invasive approaches in the treatment of urologic stones disease. The aim of this study was to compare stone free rates between these two treatment options.

Material and methods: From January 2010 to January 2011, 120 consecutive patients with single and primary ureteral stones were prospectively enrolled in this prospective study. The study was single-blinded and none of the patients knew which approach for stone fragmentation would be used.

Results: The ureteral stone-free rate (SFRs) in the PL group was 80.7% and 86.1 % in the LL group (p=0.002). The mean operating time was 60 (± 25) minutes in the LL group and 61 (± 21) minutes in the PL group, without significant differences (p=0.68). Multivariate logistic analysis revealed that stone location was not significantly predictive of SFRs (p=0.47). None of the patients had blood transfusions and no other severe complications appeared in either group.

Conclusions: In our study LL was significantly associated with a stone 80.7% in the PL group and 86.1% in the LL group (p<0.05). Also, Holmium:YAG laser lithotripsy was demonstrated to be the more efficacious endoscopic procedure for the treatment of ureteral stones, allowing stones to be successfully fragmented, with few complications.

Introduction

Over the last ten years, the treatment of urinary lithiasis has changed considerably. Traditionally, extra-corporeal wave lithotripsy (SWL) was preferred for the treatment of stones located in the kidneys and for less accessible stones located in the proximal ureters[1].

With the development of endoscopic treatment, ureteroscopy and retrograde intrarenal lithotripsy have come to play an essential role in the treatment of urinary stones located in all parts of the kidneys and ureters.

The introduction of smaller flexible and semi-rigid ureteroscopes has led to safer and more efficacious treatment methods [1].

Indeed, URS has become one of the most important techniques in the management of urinary lithiasis.

Until now, flexible URS has not been recommended as a first-line treatment for renal calculi and no valid data has been produced to support such a recommendation. However, it is worth considering as a first-line treatment for lower pole stones < 1.5 cm, given the poor results obtained with SWL in this zone. [1,3,4,5]

Moreover, URS is an efficacious technique with a low complication rate; therefore, it is

Address of the authors
[1]*Department of Urology, University of Catania, Catania, Italy*
[2]*Department of Urology, University of Sassari, Sassari, Italy*

Send correspondence to: *Giorgio Ivan Russo, giorgioivan@virgilio.it*

Received: *March 1st, 2013* — ***Revised***: *April 25th, 2013* — ***Accepted***: *May 20th, 2013*

now considered to be an efficient primary choice for the management of ureteral stones.

Different techniques, such as PL and LL, are also available for intracorporeal lithotripsy. Pneumatic lithotripsy has many advantages: relatively low cost, easy management and high stone-free rate. On the other hand, it is associated with a possibility of stone push-up, and with a higher chance of stone migration when dealing with proximal ureteral stones than with distal ureteral stones. [6]

Holmium:YAG laser lithotripsy (LL) is safe and is able to fragment all stones regardless of their composition. This technique produces a shockwave that reduces the likelihood of retropulsion of stones or stone fragments when compared to pneumatic lithotripsy (PL) [7,8,9].

Using LL, calculi are fragmented with a success rate of between 80% and 95% [10].

The aim of this study was to prospectively analyze the stone free rates between PL and LL for the treatment of ureteral stones.

Material and Methods

From January 2010 to January 2011, 120 consecutive patients with single and primary ureteral stones were prospectively enrolled in this prospective study.

The study was single-blinded and none of the patients knew which of the two treatment options for stone fragmentation would be performed. All subjects gave informed written consent before entering the study, which was conducted in accordance with the Declaration of Helsinki and the Human Ethics Committee approved the study protocol.

Subjects were randomly assigned to 1:1 ratio in two treatment groups LL and PL group.

Three patients in the PL were excluded because they were found to have anomalies of the urinary tract including 1 horseshoe kidney, 1 complete duplicated system and 1 incomplete duplicated system,

Stone size was taken as the longest diameter of the two indicated by the imaging study.

Each procedure was performed using general anesthesia with patients placed in a lithotomy position.

In the LL group, a 200 μm holmium laser lithotripsy was performed initially passing a 6/7.5F or 8/9.8F semirigid ureteroscope (Wolf™, Knittlingen, Germany) over a guidewire with fluoroscopic guidance.

We used a holmium laser machine set at an energy level of 0.5–2.0 J and a rate of 5 Hz. In the PL group, Pneumatic lithotripsy was performed using a 9 Fr rigid ureteroscope (Swiss Lithoclast). For both techniques, all the fragmented stones were extracted using a stone basket or by means of irrigation. A fluoroscopic examination was performed during surgery to ensure the correct positioning of the double J ureteral stent, which was routinely inserted at the end of each procedure. No additional therapies were required by the patients. The DJ stent was removed 4 weeks after surgery on an outpatient basis. Initial postoperative stone-free rates were determined by patient assessment at the time of hospital discharge with KUB radiography. The postoperative stone-free rate was determined at 3 months postoperatively, using a spiral CT. A stone-free status was held to be an absence of residual fragments in imagining studies. The procedure was considered successful if the patient was stone free.

A complication connected with the procedure was considered as the onset of a symptom or disease within the 30 days following surgery.

The PL and LL groups were compared using a chi-square test (Pearson χ2-test) and contingency tables. A comparison was also made between each group, considering all stone locations and using cumulative contingency tables. A result of $P<0.05$ was considered significant. All statistical analyses were completed using *SPSS v. 19 software* (SPSS Inc, IBM Corp, Somers, NY, USA).

Results

A total of 117 patients were treated from January 2010 to January 2011, 57 underwent PL and 60 LL. In the PL group, median age was 48 (range, 25-65) and the male/female ratio was 31/26. In the LL group, median age was 51 (range, 23-67) and the male/female ratio was 28/22.

Table 1 shows the baseline characteristics of our cohort. No statistical differences were observed at baseline.

The stone free rates were 80.7% in the PL group and 86.1% in the LL group (p<0.05). The mean operating time was 60 (± 25) minutes in the LL group and 61 (± 21) minutes in the PL group, without significant differences (p=0.68). A multivariate logistic analysis revealed that stone location was not significantly predictive of SFRs (p=0.47).

Fever occurred in 4 cases in the PL group and in 7 cases in the LL group; the patients were successfully treated with antibiotics.

None of the patients had blood transfusions, and no other severe complications appeared in either group.

Discussion

Medical management is the first recommended approach for a stone of less than 7 mm. When this fails and when the stone diameter exceeds 6-7 mm, active treatment is indicated.[1]. As an active treatment, URS occupies an essential place as mini-invasive techniques and their use are associated with a success rate of between 80% and 95% [10].

The standard of surgical treatment for patients suffering from ureteral calculi is to obtain a successful stone-free rate with minimal attendant morbidity. In fact, successful fragmentation of ureteral stones whatever their composition, has been reported in 73% to 100% of cases, with a mean stone-free rate of 95% [11].

However, a lower pole location has a reduced possibility of fragmentation compared to other locations.

One advantage of LL is the ability to fragment all stones regardless of composition. In addition, it produces a weak shockwave that reduces the likelihood of retropulsion of the stone or stone fragments compared to pneumatic lithotrites [7,8,9]. On the other hand, one of the advantages of ballistic lithotripsy is its relatively low cost and low maintenance. Furthermore, because no heat is produced during lithotripsy, the risk of thermal injury to the urothelium is eliminated.

The same four techniques, electrohydraulic lithotripsy, laser lithotripsy, ultrasonic lithotripsy, and pneumatic lithotripsy, are available for intracorporeal lithotripsy for ureteral stones and likewise for renal stones.

Successful fragmentation of ureteral stones whatever their composition, has been reported in 73% to 100% of cases, with a mean stone-free rate of 95%. [6,8,18,19,20,21,22]

Overall, ureterorenoscopy with LL produces excellent stone-free rates (>92%) in the treatment of proximal ureteral stones smaller than 1 cm. [23]

Tipu et al. compared the efficacy of the LL and PL in treating ureteric calculi. They included a total of 100 patients divided into two equal treatment groups, and they reported a stone-free rate at 4 weeks of 92 % in the laser group compared to 82 % in the pneumatic lithoclast group [24].

A 5-year retrospective study was conducted by Yu et al. to compare the out-

	PL group	LL group
No. Of patients	57	60
Median of age, in years (range)	51 (23-67)	48 (25-65)
Stone position (No.,%)		
proximal ureter	18 (31.58)	13 (21.66)
middle ureter	16 (28.07)	20 (33.33)
distal ureter	23 (40.35)	27 (45)
Mean ureteral stone size (mm)	10.2 (± 0.4)	11 (± 0.52)
Stone size		
> 10 mm	31 (54.38)	27 (45)
≤ 10 mm	26 (45.62)	33 (55)
Mean operation time (minutes)	61 (± 21)	60 (± 25)

Table 1: Baseline Characteristics of PL and LL group. (**PL:** Pneumatic lithotripsy; **LL**: laser lithotripsy; **PNL**: Percutaneous lithotripsy; **URS**: Ureteroscopy;)

come, safety and efficiency of pneumatic and holmium laser lithotripsy in managing upper ureteral stones. They analyzed 372 patients who underwent retrograde ureteroscopic treatment. Their stone-free rate was 90.4% and the mean operation time was 41.2 ± 10.7 minutes. Their higher post-operative stone-free rate was associated with the use of holmium laser lithotripter [25]. Nevertheless, in a more recent study by Garg et al, the immediate stone clearance rate was higher in the LL group (p = 0.001), but it was comparable at 4 weeks (p = 0.097) with PL [26].

In a recent meta-analysis that compared the effectiveness of LL and PL in the treatment of distal ureteric calculi, significant advantages of LL in improving early stone-free rate as well as delayed stone-free rate have been demonstrated. In addition, LL presented fewer incidences of calculus migration, lower mean operation time and retaining JJ catheter rate, whereas we failed to detect any significant difference between PL and LL in the ureteral perforation rate and the postoperative hematuria rate [27].

In fact, stone location may affect the stone free status of lithotripsy. An evaluation of the efficacy of semi-rigid ureteroscopy in the management of ureteral stones located in different parts of the ureter was performed by Yencilek et al. in 1,503 patients treated with PL with a success rate of 94.2%. The success rate was lower for the proximal ureter (71.7%) when compared with the mid (94.8%) and distal ureter (98.9%) (p=0.021) [28].

Our results demonstrated significantly higher stone-free rates in the group treated with the LL than in those treated with PL. However, in contrast with previous observations, success rates with regard to stone position were not significantly different between groups.

Finally, both treatment options invoked few complications without significant differences between them. Several limitations should be considered before concluding, such as the lack of a blinded radiologist and the single center characteristic of our study.

Conclusion

A comparison between Pneumatic lithotripsy and Holmium:YAG laser lithotripsy has demonstrated that the latter is associated with a higher stone-free rate.

It seems that Holmium:YAG laser lithotripsy is a more efficacious endoscopic procedure for the treatment of ureteral stones allowing stones to be successfully fragmented with few complications.

References

1.Türk C, Knoll T, Petrik A, Sarica K, Seitz C, Straub M, Traxer O; members of the European Association of Urology (EAU) Guidelines Office: Guidelines on Urolithiasis. In: EAU Guidelines, edition presented at the 25th EAU Annual Congress, Barcelona 2010. ISBN 978-90-79754-70-0.

2.Ibala DM, Assimos DG: Lower pole I: a prospective randomized trial of extracorporeal shock wave lithotripsy and percutaneous nephrostolithotomy for lower pole nephrolithiasis-initial results. J Urol 2001 Dec;166(6):2072-80

3.Obek C, Onal B, Kantay K, Kalkan M, Yalçin V, Oner A, Solok V, Tansu N: The efficacy of extracorporeal shock wave lithotripsy for isolated lower pole calculi compared with isolated middle and upper caliceal calculi. J Urol 2001 Dec;166 (6):2081-4.

4.Riedler I, Trummer H, Hebel P, Hubmer G: Outcome and safety of extracorporeal shock wave lithotripsy as first-line therapy of lower pole nephrolithiasis. Urol Int 2003;71(4):350-454.

5.Pearle MS, Lingeman JE, Leveillee R, Kuo R, Preminger GM, Nadler RB, Macaluso J, Monga M, Kumar U, Dushinski J, Albala DM, Wolf JS Jr, Assimos D, Fabrizio M, Munch LC, Nakada SY, Auge B, Honey J, Ogan K, Pattaras J,McDougall EM, Averch TD, Turk T, Pietrow P, Watkins S: Prospective, randomized trial comparing shock wave lithotripsy and ureteroscopy for lower pole caliceal calculi 1 cm or less. J Urol 2005 Jun;173(6):2005-9.

6.Knispel HH, Klän R, Heicappell R, Miller K: Pneumatic lithotripsy applied through deflected working channel of miniureteroscope: Results in 143 patients. J Endourol 1998; 12:513-515.

7.Teichman JM, Vassar GJ, Bishoff JT, Bellman GC: Holmium:YAG lithotripsy yields smaller fragments than lithoclast, pulsed dye laser or electrohydraulic lithotripsy. J Urol 1998; 159:17-23.

8.Sofer M, Denstedt J: Flexible ureteroscopy and lithotripsy with the hol-

mium:YAG laser. Can J Urol 2000; 7:952-956.
9.Vassar GJ, Chan KF, Teichman JM, Glickman RD, Weintraub ST, Pfefer TJ, Welch AJ: Holmium:YAG lithotripsy: Photothermal mechanism. J Endourol 1999; 13:181-190.
10.Floratos DL, de la Rosette JJ: Laser in urology. BJU Int. 1999 Jul;84(2):204-11 [PubMed: 10444153].
11.Lim SH, Jeong BC, Seo SI, Jeon SS, Han DH: Treatment outcomes of retrograde intrarenal surgery for renal stones and predictive factors of stone-free. Korean J Urolog. 2010 Nov;51(11):777-82
12.Grasso M, Chalik Y: Principles and applications of laser lithotripsy: Experience with the holmium laser lithotrite. J Clin Laser Med Surg 1998; 16:3-7.
13.Amón JH, Cepeda M: Retrograde intrarenal surgery (RIRS). Technical complement for cases of acute lithiasis. Actas Urol Esp. 2011 Feb;35(2):108-14.
14.Stav K, Cooper A: Retrograde intrarenal lithotripsy outcome after failure of shock wave lithotripsy. J Urol. 2003 Dec;170(6 Pt 1):2198-201.
15.Perlmutter AE, Talug C, Tarry WF, Zaslau S, Mohseni H, Kandzari SJ: Impact of stone location on success rate of endoscopic lithotripsy for nephrolithiasis. Urology. 2008 Feb; 71(2): 214-7.
16.Bader MJ, Gratzke C, Walther S, Weidlich P, Staehler M, Seitz M, Sroka R, Reich O, Stief CG, Schlenker B: Efficacy of retrograde ureteropyeloscopic holmium laser lithotripsy for intrarenal calculi >2 cm. Urol Res. 2010 Oct;38(5):397-402.
17.Riley JM, Stearman L, Troxel S: Retrograde ureteroscopy for renal stones larger than 2.5 cm. J Endourol. 2009 Sep;23 (9):1395-8.
18.Cimino S, Sortino G, Favilla V, Castelli T, Madonia M, Sansalone S, Russo GI, Morgia G. Polyphenols: key issues involved in chemoprevention of prostate cancer. Oxid Med Cell Longev. 2012;2012:632959.
19.Gould DL: Retrograde flexible ureterorenoscopic holmium-YAG laser lithotripsy: The new gold standard. Tech Urol 1998; 4:22-24.
20.Morgia G, Cimino S, Favilla V, Russo GI, Squadrito F, Mucciardi G, Masieri L, Minutoli L, Grosso G, Castelli T. Effects of Serenoa Repens, Selenium and Lycopene (Profluss®) on chronic inflammation associated with Benign Prostatic Hyperplasia: results of "FLOG" (Flogosis and Profluss in Prostatic and Genital Disease), a multicentre Italian study Int Braz J Urol Vol. 39 (2): 214-221, March - April, 2013.
21.Aghamir SK, Mohseni MG, Ardestani A: Treatment of ureteral calculi with ballistic lithotripsy. J Endourol 2003; 17:887-890.
22.Sebastiano C, Vincenzo F, Tommaso C, Giuseppe S, Marco R, Ivana C, Giorgio R, Massimo M, Giuseppe M. Dietary patterns and prostatic diseases. Front Biosci (Elite Ed). 2012 Jan 1;4:195-204
23.Wu CF, Shee JJ, Lin WY, Chen CS: Comparison between extracorporeal shock wave lithotripsy and semirigid ureterorenoscope with holmium:YAG laser lithotripsy for treating large proximal ureteral stones. J Urol 2004; 172:1899-1902.
24.Tipu SA, Malik HA: Treatment of ureteric calculi--use of Holmium: YAG laser lithotripsy versus pneumatic lithoclast. J Pak Med Assoc. 2007 Sep;57(9):440-3.
25.Yu W, Cheng F, Zhang X, Yang S, Ruan Y, Xia Y, Rao T: Retrograde ureteroscopic treatment for upper ureteral stones: a 5-year retrospective study. J Endourol. 2010 Nov; 24(11):1753-7.
26.Garg S, Mandal AK, Singh SK, et al. Ureteroscopic laser lithotripsy versus ballistic lithotripsy for treatment of ureteric stones: a prospective comparative study. Urol Int. 2009;82(3):341-5.
27.Yin X, Tang Z, Yu B, Wang Y, Li Y, Yang Q, Tang W (2013) Holmium: YAG Laser Lithotripsy Versus Pneumatic Lithotripsy for Treatment of Distal Ureteral Calculi: A Meta-Analysis. Journal of endourology / Endourological Society 27 (4):408-414.
28.Yencilek F, Sarica K, Erturhan S, Yagci F, Erbagci A: Treatment of ureteral calculi with semirigid ureteroscopy: where should we stop? Urol Int.. 2010;84(3):260-4.