ORIGINAL ARTICLES

COMPARATIVE ANALYSIS OF SEMI RIGID URETEROLITHOTRIPSY AND EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY FOR THE TREATMENT OF UPPER URETERIC CALCULI

ATM AMAN ULLAH[1], ISTEAQ AHMED SHAMEEM[1], AKM KHURSIDUL ALAM[1], MD GOLAM MOWLA CHOWDHURY[1], AKM ANWARUL ISLAM[1], SAMG KIBRIA[1]

[1]Department of Urology, Bangabandhu Sheikh Mujib Medical University, Dhaka

Abstract:

***Objectives**: To find out the better treatment option between semi rigid ureteroscopy with ICPL and ESWL for upper ureteric calculi. To compare stone free rate, complications and re treatment between ureterolithotripsy and ESWL in upper ureteric calculi.*

***Materials and Method:** This prospective comparative study was conducted in the department of urology BSMMU and Kidney and urology hospital, Dhaka from June 2009 to May 2010. Fifty patients were enrolled and 25 on each group as ESWL and ICPL Inclusion criteria was adult patients with single radiopaque stone of 06-15 mm, and no obstruction distal to stone. We exclude Stone size > 1.5cm, PUJ stone, patients with DJ stent and nephrostomies, infection, pregnancy, hemostatic, disorders, and morbid obesity. Identified postoperative urological complications pain, haematuria, fever, stone migration, obstruction, infections, and postoperative hospital stays recorded accordingly. X- ray KUB and in some cases ultrasound of kidney ureter and bladder with prostate with PVR were done. Those with residual calculi sized less than 2 mm were considered stone free. Those patients whom stone not cleared or stone migrated they again sent for ESWL or ureterolithotripsy. Stone free patient of ureterolithotripsy sent for removal of Double J stent under local anesthesia at 4 weeks.*

***Results:** Three months postoperatively, 21 out of 25 Patients (85%) in the ureterolithotripsy group were stone free. In ureterolithotripsy group, all failures were due to upward calculus migration. After calculus migration, this was mandated double-J stenting and send for ESWL. These patients were referred for ESWL, all of whom were stone free after this procedure. DJ stent removed under local anesthesia. 22 out of 25 Patients (88%) in the ESWL group were stone free and 10 patients need two sessions. Re-ESWL had done after 3 weeks. All failures in ESWL group were due to hard in constancy and small stone size. Failed cases were referred for ureterolithotripsy and DJ stenting, all of whom were stone free after this procedure. Using statistical data by chi square test and analytical test level of significance as set at 0.05 and p< 0.05 was consider significant.*

***Conclusion:** Upper ureteral calculi up to 1.5 cm can be safely and effectively managed by using semi rigid ureteroscopy and pneumatic lithotripsy. However, the ESWL approach has still its role in treating upper ureteric calculi. Finally, postoperative home rest in the ESWL group was more due to the repeated treatment.*

***Key words**: upper ureteric calculi, semi rigid ureteroscopy, ureterolithotripsy, ESWL.*

Bangladesh J. Urol. 2017; 20(2): 54-60

Correspondences: Dr. ATM Aman Ullah, Department of Urology, Bangabandhu Sheikh Mujib Medical University and Kidney and Urology Hospital Ltd, Dhaka

Introduction:

Ureteric calculus is a very common urological problem. There is no data about diagnosed or treated case of ureteric stone. The optimal treatment option for ureteral calculi is a controversial issue. For upper ureteral calculi, the options are extracorporeal shockwave lithotripsy (ESWL) with or without calculus manipulation, ureteroscopy with intracorporeal lithotripsy (ureterolithotripsy), percutaneous nephrolithotomy (PCNL) and rarely open or laparoscopic surgery[1]. Open surgical procedures for the treatment of ureteric stones have gradually disappeared in the last 30 years due to the emergence of increasingly efficacious minimally invasive techniques such as ESWL and ureteroscopy. This is due to a parallel advancement in technologies in both the fields.

The success rate reported in the range of 86% to 100% following ureteroscopic management using different ureteroscopes and intracorporeal devices[2]. The rate of serious complications such as ureteric perforation and development of stricture has decreased by miniaturization of instruments. The rate of ureteric perforation and stricture formation is around 2%to 4% and 0% to 2% respectively following ureteroscopic procedure of ureteric calculi[2,3].

On the other hand, the reported success rate following ESWL has been 80% to 100% in different studies[1]. Non-invasive nature, acceptance and outpatient treatment are the attractive attributes of ESWL treatment. In the American Urological Association's 'Ureteral Stones Clinical Guidelines Panel summary report on the management of ureteral calculi', ESWL is recommended as first line treatment for most patients with stones 1 cm or less in the proximal ureter. These are countered by proponents of ureteroscopy with immediacy of stone-free rate.

There are randomised trials[2,3] reported since the publication of these recommendations and it was felt worthwhile to carry out a systematic review in order to address this question. It remains uncertain if one treatment modality is better than the other and which calculi are best suited to a particular modality of treatment. The considerable variability in their use even within a single healthcare system such as the National Health Service (UK) reflects this uncertainty. It is therefore important to determine whether any one treatment has important clinical benefits in the management of ureteric calculi.

When a ureteral stone treatment is actively needed, the choice of best procedure is dependent on several factors, besides stone size and location, including patients' preference, operators' experience, available equipment and involvement of cost [6]. Ureteroscopy with intracorporeal pneumatic lithotripsy (ICPL), extracorporeal shockwave lithotripsy and open operations currently represents the mainstay of treatment for upper ureteral stone in our setting, which is yet practice in peripheral hospitals.

ESWL is the most popular form of management for upper ureteric stones, because of its low morbidity, non-invasiveness and acceptable efficacy. Modern ureteroscopes and intracorporeal lithotripsy also share good safety profiles but are more often utilized for distal ureteric stones and lithotripsy failures.

Developments in ureteroscope and laser design has resulted in easier access to the entire ureter and greatly decreased complication rate making ureterolithotripsy management of proximal ureteric stones much more attainable. The available comparative series show superior efficacy for ureterolithotripsy over ESWL in the management of upper ureteric calculi[10]. However, in our country there is no such study between ureterolithotripsy vs ESWL for proximal ureteric stones.

Material and methods:

Study design

Prospective study was carried out in June 2009 to May 2010 for patients of primary treatment of solitary radio opaque, upper ureteric stone attend in urology outpatient department of Bangabandhu Sheikh Mujib Medical University (BSMMU) and Kidney and urology hospital (Pvt) Ltd Dhaka. Selected patients were evaluated by history, physical examination and relevant investigations. All patient of stone diseases were reviewed and identify new case of single stone of upper ureter.

Sample size:

50 Patients are divided in two groups after simple random sampling. Group- 1 for ureterolithotripsy (URS) and Group II for extracorporeal shock wave lithotripsy (ESWL). After discussing the available therapeutic modalities with their advantages and disadvantages, we select 25 patients in Group I and 25 patients in Group II.

Independent variables are age of patients, sex, side of stone, and size of stones, and dependent Variables are stone clearance , complication, and re- treatment ESWL or ureterolithotripsy.

Patient Selection: inclusion criteria was adult patients with single radio opaque of 0.6-1.5 cm no obstruction distal to stone. Exclusion criteria was stone size > 1.5cm,, PUJ stone, patients with DJ stent and nephrostomies, infection, infection, pregnancy, hemostatic disorders, and morbid obesity

Study method:

History and clinical evaluation

Detail history was taken and clinical examination was done for each patient, informed written consent was taken from each patient (Appendix-I) and were recorded in a predesigned checklist (Appendix-II).

Preoperative evaluation

All of the patients underwent preoperative ultrasonography, intravenous urography, and routine laboratory tests including complete blood count, Urine RME, culture and sensitivity, Blood sugar, Blood urea, Serum creatinine, X-Ray chest P/A view, ECG, bleeding and clotting times.

Operative procedure

In the ureterolithotripsy group, the patients were admitted to the hospital preoperatively. On the day of operation, calculus location was being checked by plain X- ray KUB. The procedure was carried out under spinal anesthesia Parental antibiotics was given before induction of anesthesia. Ureteroscopic evaluation was done by using a semirigid 8-9.5 Fr Wolf ureteroscope (Richard Wolf GmbH, Knittlingen, Germany), guide wire and pneumatic Swiss Lithoclast (Electro Medical Systems, Le Sentie, Switzerland) was used with a 0.8-mm probe for calculus fragmentation. To avoid migration of calculi, low-pressure fluid stream and in some cases 2.8 Fr of 145 cm length Stone entrapment and extraction device (stone cone, Cook Urology) was used. Double-J ureteral stent of 5-6 Fr were placed and kept for 4 weeks. During discharge per rectal analgesic, antibiotics, in some cases hydrochlorothiazide were given and excessive fluid consumption for 3 months postoperatively were recommended.

The ESWL was performed after 8 hours of fasting, overnight, and mild intestinal preparation with oral ultra carbon and laxenna. Patients were admitted in hospital. Electromagnetic machine (Siemens Lithoskop, Siemens, Germany) was used for lithotripsy of a maximum 2 sessions (1 session every 3 weeks) with 2000 shocks per session using a power of 3 kV to 4.7 kV. During the ESWL, 1000 ml of normal saline was administered intravenously and per rectal Diclofenac suppository 50 mg were used. All of the patients were discharged on the same day with per rectal analgesics, antibiotics and diuretic (hydrochlorothiazide, 50 mg per 12 hours) in some cases. Excessive fluid consumption was also recommended to the patients for 3 months.

Postoperative pain, haematuria, obstruction, infection, re-treatment and other complications of both therapeutic approaches were recorded in Data sheet.

Postoperative evaluation

Identified postoperative urological complications pain, haematuria, fever, stone migration, obstruction, infections were managed accordingly and recorded. Postoperative hospital stay also recorded for each patient.

Follow up evaluation

Postoperative patients were followed up at 3 weeks and continued for three months. No one escaped follow up. In the follow up study, history taking, clinical examination and investigations, urine RME, urine culture and sensitivity, blood urea, serum creatinine, X- ray KUB and in some cases ultrasound of kidney ureter and bladder with prostate with PVR were done. Those with residual calculi sized less than 2 mm were considered stone free. Those patients whom stone not cleared or stone migrated they again sent for ESWL or ureterolithotripsy. Stone free patient of ureterolithotripsy sent for removal of Double J stent under local anesthesia at 4 weeks. Success rate and complications of both therapeutic approaches were recorded in data sheet.

Ethical Consideration:

All patients were given an explanation of the study and informed written consent was taken from each patient as per instructions of the ethical committee.

Data Collection Method:

Collection of the data and evaluate the relevant investigations done in both indoor and outpatient Department. Postoperative follow-up had performed after 3 weeks and up to 3 months in the same place. A data sheet filled up during data collection. Success rate and complications of both therapeutic approaches were compared. For statistical analyses, SPSS 11.5 version was used.

Observation and result:

This prospective comparative study was carried out in the department of urology BSMMU and Kidney and urology hospital private Ltd, Dhaka from June 2009 to

May 2010. Total 50 cases of upper ureteric stones were included in this study. Among 50 patients, twenty-five were grouped for ureterolithotripsy (group 1) and twenty-five for ESWL (group 11).

General characteristics of both group such as age of patient, sex, stone side and stone size was recorded.

In ureterolithotripsy group total no's of patients was 25 and of them 5 were female. Age range was 22-65 years, mean (±SD) age of was 36.00 (±12.32) years. Age ranges were male 22-62 years and female 25-65 years. Side of stone 11 left side and 14 right sides. Size of stones was 06-15 mm. Stone size was categorized as 06 to 10 and 11 to 15mm. In this group 06-10 size stone were numbers 11 and other was 14. In all cases clearance distal to stone was present and only two cases of mild hydronephrosis.

In ESWL group total no's of patients was 25 and of them 6 female. Age range was 22 –62 years, mean (±SD) age of was 34.24 (±10.52) years. Age ranges were male 22-62 years and female 26-61 years. Side of stone 12 left side and 13 right sides. Size of stones was 07-15 mm. .In this group 06 to 10 mm size stone was numbers 12 and other was 13. In all cases clearance distal to stone was present and no hydronephrosis.

In ureterolithotripsy group**,** 25 patients 20 (80%) was male and rest 5 (20%) female. Stones were right-sided 14 and left 11 cases. Stone size was in ureterolithotripsy ranges from 7 mm to 15 mm and mean was 10.56 (±2.48). In ESWL group, among 25 patients 19 (76%) were male and 6(24%) female. Stones were right-sided 13 and left side 12 cases. Stone size was in ESWL ranges from 7 mm to 15 mm and means was 10.64 (±1.99).

Characteristics of the patients in this study ureterolithotripsy and ESWL group shown in Table -1.

Three months postoperatively, 21 out of 25 Patients (85%) in the ureterolithotripsy group were stone free (Table-II). In ureterolithotripsy group, all failures were due to upward calculus migration. After calculus migration, this was mandated double-J stenting and send for ESWL. These patients were referred for ESWL, all of whom were stone free after this procedure. DJ stent removed under local anesthesia. Their calculi size ranged from 6 mm to 15 mm.

22 out of 25 Patients (88%) in the ESWL group were stone free and 10 patients need two sessions (Table-II). Re-ESWL had done after 3 weeks. All failures in ESWL group were due to hard in constancy and small stone size. Failed cases were referred for ureterolithotripsy and DJ stenting, all of whom were stone free after this procedure. Their calculi size ranged from 7 mm to 15 mm.

Table-I

Summarizes the characteristics of the patients in this study ureterolithotripsy and (ESWL) group.

Character		Ureterolithotripsy group	ESWL group
Number of patients		25	25
Sex	Male	20 (80%)	19 (76%)
	Female	05(20%)	06(24%)
Age Range		22-65 years	22-62 years
Mean age (years)		36.00 (±12.32) years	34.24 (±10.52)years
Side of stone	Right	11	12
	Left	14	13
Stone size Range		06-15 mm	07-15 mm
Mean stone size		10.56 (±2.48).	10.64 (±1.99).

sTable II

Comparison of Stone free between ureterolithotripsy and ESWL by using chi square test (X^2) test.

Methods	Success	Failed	degree of freedom(df)	X^2Value	p value
ureterolithotripsy	21	04	1	.166	.684
ESWL	22	03			
Total	43	07			

* Insignificant

Ureterolithotrypsy group no patients developed obstruction and in ESWL group one patient developed obstruction with symptoms. Comparison of obstruction between groups is shown in Table III.

Table -III

Comparison of postoperative obstruction stone free between ureterolithotripsy and ESWL by using chi square test (X^2) test.

Methods	No obstruction	Obstruction	Degree of freedom (df)	X^2 value	p value
Uretero-lithotripsy	25	00	1	1.020	.312
ESWL	24	01			
Total	49	01			

*Insignificant

During 3 months of study period 11 patients suffered from UTI, of them 8 patients had single episode and 1 patients had recurrent episodes of UTI were presented with pyuria, bacteriuria and fever. In ureterolithotripsy 5 patients had urinary tract infection (UTI). After urine culture organism isolated were Escherichia coli (3), pseudomonus aeroginosa (1), and staphylococcus epidermis (1). One patient had recurrent UTI with same organism. In ESWL patients, 6 patients had urinary tract infection (UTI). After urine culture organism isolated were Escherichia coli (3), pseudomonus aeroginosa (2) and Enterococci (1). (Table IV).

Table -IV

Comparison of postoperative infection between ureterolithotripsy and ESWL by using chi square test (X^2) test.

Methods	No infection	Infection	degree of freedom(df)	X^2 Value	p value
Uretero-lithotripsy	20	05	1	.177	.733
ESWL	19	06			
Total	43	07			

*Insignificant

In ureterolithotripsy group 4 patients need ESWL for stone free but in ESWL group 10 patients went second session, among them 3 patients failed to stone free by ESWL. These patients were stone free by ureterolithotripsy. Those patient needs extra session and other treatment modality were level re treatment.

Table -V

Comparison of re treatment between ureterolithotripsy and ESWL by using chi square test (X^2) test.

Methods	Treatment	Re treatment	degree of freedom(df)	X^2 Value	p value
uretero-lithotripsy	21	04	1	4.667	.031
ESWL	15	10			
Total	36	14			

* Significant

Double-J stent was inserted and retained for 4 weeks in ureterolithotripsy group and ESWL failed patients. Postoperative pain was mild to moderate and limited hematuria were the most frequent complications in the patients of the ESWL Severe pain observed in one case of ESWL group and need parental antibiotics, analgesics. Ureterolithotripsy and Double J stenting were done. Finally, postoperative home rest in the ESWL group was more due to the repeated admissions to the hospital.

Discussion

There are no prospective randomised trials to compare ureterolithotripsy and ESWL for the treatment of upper ureteric calculi in our country. Treatment of ureteral calculi were chosen depending on some factors location and size of the ureteral calculus, associated pain, anatomic variations, infection, patient's choice, cost and equipment's availability. The length of time a calculus remains in the ureter becomes significant when obstruction occurs; even with complete ureteral obstruction, irreversible loss of kidney function does not occur before 2 weeks, but it can progress to total renal unit loss in 6 weeks [7]. A study on 54 patients with ureteral calculi showed that 28% of patients had impairment of kidney function at presentation. Interestingly, small calculi were as likely to cause impaired kidney function as larger calculi. Patients who underwent early intervention (within less than 7 days) had a better outcome than did patients with delayed intervention [8].

Because the patient's symptoms and calculus size do not predict loss of kidney function, and because there is no clear time threshold for irreversible damage, intervention should be strongly considered in any patient

with ureteral obstruction unless close monitoring of kidney function is available. We considered every ureteral calculus sized greater than 5 mm that had not responded to symptomatic or conservative therapy as a urologic emergency.

The panel on ureteral calculi clinical guideline of the American Urological Association suggested that ESWL, by whatever technique (push-back or in situ), should be the primary approach for calculi smaller than 1 cm in the proximal ureter [4]. This recommendation is based on a meta-analysis of all articles on ureteral calculi published over a 30-year period from 1966 to 1996. The results were analyzed for ESWL in situ, ESWL after pushback technique, ESWL after stent insertion, PNL, ureteroscopy, and open calculus surgery. For calculi smaller than 1 cm in diameter, the stone free rates by ESWL and ureterolithotripsy were 84% and 56%, respectively, and for calculi larger than 1 cm, 72% and 44%, respectively.

Study conducted by Mohammad Reza Nikoobakht on 2007 revealed better success rate with ureteroscopic approach, especially in-patients with higher grades of hydronephrosis. Stone-free rates were 76.9% in the patients of ureterolithotripsy group and 68.8% in the patients of ESWL group. These results were similar to the results of a study by Yagisawa and associates [9]. They compared ESWL and ureteroscopy with pneumatic lithotripsy for impacted ureteral calculi, and although the stone-free rate at 1 month was 100% for patients treated with ureteroscopy, all the calculi treated by ESWL required further auxiliary endoscopic manipulation.

In our study Stone-free rates were 84% in the patients of ureterolithotripsy group and 88% in the patients of ESWL group. Stone free rate in stone size 06-10 mm was 91.67% in ESWL and that in stone size 11-15 mm was 92.87% in ureterolithotripsy.

However, ESWL machines are still nonportable and expensive. On the other hand, the portability, cost efficacy, and durability of pneumatic lithotripters and semirigid ureteroscopes make ureterolithotripsy an approach comparable with ESWL for small upper ureteral calculi. Especially, with regard to the advent in anesthetic approaches for such interventions, ureterolithotripsy can be a treatment option. However, patients with nonimpacted upper ureteral calculi should be referred directly for ESWL, while it is much reasonable to refer those with impacted calculi for ureterolithotripsy.

A review of the literature shows excellent results for ureteroscopic lithotripsy using the holmium laser for proximal as well as distal ureteral calculi, with a mean stone free rate of 95% associated with a low perforation and stricture rate of about 1%. These results are equivalent or superior to the results achieved by ESWL for upper ureteral calculi. [1,10].

In our settings we have no laser machine, we used pneumatic Lithoclast, despite the risk of calculus migration with this type of management, we used stone cone but still its low cost, portability, availability, and durability in comparison with laser machines, makes it attractive in our country.

Calculus composition is another challenge to decision making. Spiral noncontrast computed tomography (CT) can predict calculus composition by using CT attenuation values [9]. It may become a valuable aid in determining ureteral calculus composition before treatment. This excessive evaluation may add extra cost to ESWL approach, while there is no need for determining calculus composition before ureterolithotripsy.

The only real challenge to the use of ureteroscopic approach plus pneumatic lithotripsy for the management of upper ureteral calculi is upward calculus migration, especially in those without hydronephrosis or with mild hydronephrosis. This issue was previously resolved by using holmium laser for calculus fragmentation with high safety and success rate . but still the cost burden of laser machine and probe are the limitations. We resolved this problem by using weak irrigation stream system once reaching the calculus with or without using additional auxiliary devices (Stone entrapment and extraction device). If required, by closing the input and opening output irrigation access to make reciprocal downward stream that helped to draw the calculus towards the lithotripter probe and ureteroscope head. In our study calculus migration was only 4 cases that is about 16%. Mohammad Reza Nikoobakht on 2007 shows that stone migration was 23.1%. This is low in our setting.

Obstruction after procedure was observed only one case in ESWL group, this patient need hospitalization, treated with analgesic and injectable antibiotic and stone free by ureterolithotripsy and DJ stenting. But Mohammad Reza Nikoobakht on 2007 Shows obstruction with pain occurred in 16.7% patients. Infections and fever was observed 5 patients in ureterolithotripsy and 6 patient in ESWL in this study is 22% in both groups and it was insignificant.

In ureterolithotripsy cases 4 stone migrated upwards and they were stone freed by ESWL but in ESWL cases only 15 patients was stone free by single session, remaining 10 patients needed two session of ESWL. Each session was 3 weeks interval. After 6 weeks, 3 patients stone free done by ureterolithotripsy. In ESWL group re treatment is vary high, that is 40% and in ureterolithotripsy cases it is only 16%. GD Stewart 2007 showed re treatment in case of ESWL was 25.9% and ureterolithotripsy casing 11.1%. Removal of stent as an ancillary procedure in case of ureterolithotripsy was 25 and in ESWL were 3case.

We observed that ESWL is better for smaller size stone (06-10), those with no hydronephrosis and is more suitable for larger size stone (11-15), those with mild hydronephrosis.

Mild to moderate pain was observed in all cases except one case of ESWL, which needs multiple dose of analgesic. For relieve pain we used Diclofenac suppository 50 mg in both group and as sedative injectable Diazepam. Hematuria was another complication in both cases, there was mild hematuria in all cases and no patient need for blood transfusion.

Finally, this study showed that the experience and preference of the endourologist in management of upper ureteric calculus may change present treatment modalities.

Conclusion:

Upper ureteral calculi up to 1.5 cm can be safely and effectively managed by using semi rigid ureteroscopy and pneumatic lithotripsy with use of stone cone. However, the ESWL approach has still its role in treating upper ureteric calculi.

Limitation of study:

1. Small size study population
2. Long term follow up is needed.
3. Needs well equipped center for Endo-urology.

References:

1. Nikoobakht MR1, Emamzadeh A, Abedi AR, Moradi K, Mehrsai A. Transureteral lithotripsy versus extracorporeal shock wave lithotripsy in management of upper ureteral calculi: a comparative study. Urol J. 2007 Fall;4(4):207-11.
2. Pearle MS, Nadler R, Bercowsky E, Chen C, Dunn M, Figenshau RS,et al. Prospective randomized trial comparing shock wave lithotripsy and ureteroscopy for management of distal ureteral calculi. *Journal of Urology* 2001;166(4):1255–60.
3. Wu CF, Chen CS, Lin WY, Shee JJ, Lin CL, Chen Y, Huang WS. Therapeutic options for proximal ureter stone: extracorporeal shock wave lithotripsy versus semirigid ureterorenoscope with holmium:yttrium-aluminum-garnet laser lithotripsy. *Urology* 2005; 65(6):1075–9.
4. Segura JW, Preminger GM, Assimos DG, Dretler SP, Kahn RI, Lingeman JE, et al. Ureteral Stones Clinical Guidelines Panel summary report on the management of ureteral calculi. The American Urological Association. *Journal of Urology* 1997;158(5):1915–21.
6. Osorio L, Lima E, Soares J, Autorino R, Versos R, Lhamas A, et al. Emergency ureteroscopic management of ureteral stones: Why not? Urol 2007;69:27-31.
7. Vaughan ED Jr, Gillenwater JY. Recovery following complete chronic unilateral ureteral occlusion: functional, radiographic and pathologic alterations. J Urol. 1971;106:27-35.
8. Irving SO, Calleja R, Lee F, Bullock KN, Wraight P, Doble A. Is the conservative management of ureteric calculi of > 4 mm safe? BJU Int. 2000;85:637-40.
9. Mostafavi MR, Ernst RD, Saltzman B. Accurate determination of chemical composition of urinary calculi by spiral computerized tomography. J Urol. 1998;159:673-5.
10. Portis AJ, Yan Y, Pattaras JG, et al. Matched pair analysis of shock wave lithotripsy effectiveness for comparison of lithotriptors. J Urol 2003; 169: 58-62.