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Original Article

The outcome of pneumatic lithotripsy for the management of ureteric calculi

Shrestha B, Karki DV, Baidya JL

Department of Urology & Surgery, B & B Kathmandu University Teaching Hospital, Lalitpur, Nepal.

Abstract

Background: Various methods have been adopted for the removal of ureteric calculi around the world. Ureteroscopic pneumatic lithotripsy has been used to treat ureteric calculi for more than a decade. Owing to its low price and high degree of effectiveness, it has become the most popular ureteroscopic device amongst many others. Moreover, ureteroscopy has become the method of choice for the quickest way of rendering patients stone-free.

Objectives: To determine successful stone fragmentation by ureteroscopic pneumatic lithotripsy in the management of ureteric calculi as well as intra-operative and post-operative complications related to it.

Study design: A prospective and descriptive study. The study was conducted in Section of Urology, Department of Surgery, B&B Teaching Hospital, Kathmandu University. The data was collected from April 2005 to April 2006.

Materials and methods*:* Ninety-two consecutive patients having ninety-five ureteric stones were treated with intracorporeal pneumatic lithotripsy over a period of one year. The size, side, number and site of stones along with the results of preoperative routine investigations were noted in the patients. The pneumatic lithotripter was introduced through a 10 or 8 Fr rigid ureteroscope (Karl Storz*)* to break the stone/s. Successful stone fragmentation, lithotripsy time, intra-operative and post-operative complications and duration of hospital stay were recorded.

Results: Complete stone fragmentation was achieved in about 80 % of cases. The mean lithotripsy time was 17.66 minutes. About 76% of patients were stone-free at one week follow-up after the procedure, 92% by the end of eight weeks while 100% stone-free status was achieved by the end of 12 weeks. The mean hospital stay was 1.82 days and complications (both significant and minor) occurred in 51 % of cases. However, majority of them were minor and successfully managed.

Conclusion: Intra-operative pneumatic lithotripsy is a minimally invasive, effective and rapid procedure for the management of ureteric calculi. Though it can give rise to considerable complications, they are mainly minor. Moreover, both complications and failure rates can be reduced if patients with ureteric calculi are properly selected. It seems to be a good alternative in patients where extracorporeal shockwave lithotripsy is unsuccessful or not indicated and in patients who need early stone removal.

Key words: SIRS- Systemic Inflammatory Response Syndrome, ESWL- Extra corporeal shockwave lithotripsy, JJ stent: Double J stent, URS: Ureterorenoscope, Steinstrasse.

Urinary stones have plagued humans since the earliest record of civilization. Following urinary tract infections and prostatic pathologies, they are the third most common conditions affecting the urinary tract[1]. A high incidence of urolithiasis have been reported in the countries lying in the Afro-Asian stone belt (Egypt, Sudan, Middle East, India, Pakistan, Burma, Thailand, Indonesia and Philippines), that fall within the tropical and sub-tropical regions[2].

In Nepal, true figures about the prevalence of stone disease are not available; however, it is not uncommon. In our hospital where urological workload is high, a surgical audit of two and half years from 1st June 2002 till 30th November 2004 has shown that 32% of our surgical workload was from urology. Moreover, 51% of these were due to urolithiasis. Amongst urolithiasis, ureteric calculus was the commonest disorder (65%), being managed at our hospital.

Various methods have been adopted for removal of ureteric calculi around the world. Treatment can be expectant or by removal of the stones. Spontaneous passage of stone depends on stone size, shape, location

Correspondence
Dr. Binod Shrestha
Department of Urology & Surgery,
B & B Kathmandu University Teaching Hospital,
Lalitpur, Nepal.
E-mail: drbinshrestha@yahoo.com

and associated ureteric oedema (which depend on the length of time that a stone has been impacted). Ureteric calculi 4- 5 mm in size have a 40-50% chance of spontaneous passage. In contrast, calculi more than 6mm have a less than 5% chance of spontaneous passage. However, this does not mean that a 1-cm stone will not pass or that a 1- to 2- mm stone will always pass uneventfully[1]. Non- steroidal anti-inflammatory drugs are used for pain along with smooth muscle relaxants. Various types of dissolution agents have also been used for dissolving stones[3].

Stone removal may be done by Extracorporeal Shockwave Lithotripsy (ESWL), endoscopically or by open surgery. In the developed countries, open surgical stone extraction is almost non- existent comprising only 0.5% of all cases of ureteric calculi[4]. The advent of ESWL in the early 1980s and ultra-thin ureteroscope in the early 1990s have revolutionized the management of these calculi. ESWL is non-invasive with a success rate of 84% for upper ureteric calculi. But the efficacy is lower in the middle and lower ureter due to poor accessibility, impacted stones in former and small stones in the latter. Overall success rate ranges between 58% and 72%. Another limitation of ESWL is the high rate of re- treatment sessions (38%) and high cost[5].

Laser lithotripsy was first introduced commercially in the late 1980s with the pulsed dye laser. The first pneumatic lithotripter was the Swiss Lithoclast, developed at the University Teaching Hospital in Lausanne, Switzerland in 1989. It works along the principle of jack-hammer[6]. A projectile in the hand piece is propelled by compressed air through the probe. The compressed air originates from a small generator that is connected to a dry, clean air supply. The ballistic energy produced is conveyed to the probe base at a rate of 12 Hz[6]. Continued impaction of the probe tip against the stone results in stone breakage once the tensile forces of the calculus are overcome.

Materials and methods

The study was conducted at the B&B Teaching Hospital, Kathmandu University, Lalitpur, Nepal. Among the patients who were diagnosed as having ureteric calculi, most received some form of interventions and among those who did, the majority underwent intracorporeal pneumatic lithotripsy. Purposive sampling technique was used and the total sample size was 92 over the period of study. It was a prospective study. All patients of both gender, aged 16 and above, presenting with pain abdomen, lower urinary tract symptoms and obstructive uropathy, in whom investigations have revealed ureteric calculi. Patients aged <16 years or in whom ureteric orifice cannot be negotiated by the ureteroscope were excluded from the study. The results of X- ray KUB in terms of visualization of stones were grouped as stone visualized, stone not visualized, doubtful. Intravenous Urography was performed in selective cases and so does the ultrasonography. Patients were labelled as urosepsis when one had two or more features of Systemic Inflammatory Response Syndrome (SIRS) along with isolation of organisms in urine culture. Significant post operative pain was defined as the pain requiring parenteral form of analgesics to alleviate pain symptom.

Results

A total of 92 patients underwent intracorporeal pneumatic lithotripsy out of which 7 patients had previous history of surgery for the urinary stones. The youngest subject was 16 years old; the eldest being 61 years of age with the mean age was 33.79 years.

In the study group, stone was visualised by Plain X-ray Kidney Ureter Bladder (KUB) in 81.52% of cases but not seen in 8.69 % cases. In 9.78% of cases, the results were doubtful.

Fifty one patients in the study group underwent Intravenous Urography (IVU) studies. In 92.15% of the patients who had IVU, definite conclusions could be drawn while in the rest (7.84%), the findings were inconclusive to establish a diagnosis. These stones were later picked up by ultrasound imaging. Overall, 33 patients had ultrasonogram done. Stone was visualised in about 24% of them (8 patients). Hydronephrotic changes were noted in about 70 % (23 patients). But in about 24% of cases who had USG, the findings were inconclusive.

Usually, intracorporeal pneumatic lithotripsy is performed under general anaesthesia.

In the present study, majority of patients underwent the procedure under general anaesthesia (70.7%). However, about 17% of patients underwent the procedure under spinal anaesthesia. Moreover, due to the lack of fitness for GA, patient refusal or high cost of general anaesthesia, about 9% patients opted for caudal anaesthesia and 3.3% under intravenous sedation.

In the present study, about 61% of stones required 10-19 minutes of lithotripsy time, about 33% required 20-29 minutes and 6.5% required 30-39 minutes for the procedure. Size of the stones varied from the smallest 4 mm diameter to the largest with 22 mm diameter. Majority of the stones had sizes ranging from 6 to10 mm diameter (67.4%) followed by 11-20 mm (21.7%). Only 8.7 % of patients had stone size less than or equal to 5 mm diameter. We had two patients with stone size of 22 mm diameter. A single session of pneumatic lithotripsy was performed in all patients.

The time taken for lithotripsy varied in the patients. The minimum time required for the procedure was 10 minutes while the maximum time taken was 39 minutes. The mean time taken for lithotripsy was 17.66 minutes.

In the present study, about 57% of patients had stone in the lower third of ureter, followed by about 28 % in the middle third while the upper third being the least common site of ureteric stones (about 15 %).

In the present study, all of the stones that were incompletely fragmented subsequently migrated upwards to the kidney due to the ballistic force of the lithotripter. Complete fragmentation was achieved in 88.5 %, 77% and 57.1% of calculi in the lower, mid and upper of ureter respectively.

As shown in the table, 20.65% of patients undergoing pneumatic lithotripsy required an additional procedure owing to various reasons including incomplete stone fragmentation, upward stone migration to the kidney or due to serious complications.

Here, a total of 11.95% (11 patients) required double J (JJ) stenting due to incomplete fragmentation of stones and subsequent slippage of stones into the kidney.

On the other hand, a total of 10 patients (10.86%) required extracorporeal shockwave lithotripsy (ESWL) owing to upward migration of stone or its fragment which was considered to be too big for spontaneous passage through the urinary tract.

This group also includes 3 (3.2%) patients where since JJ stenting was unsuccessful, ESWL was performed subsequently. One patient underwent open surgery for repair of avulsed ureter.

Two patients presented with severe colicky abdominal pain then stone steinstrasse was revealed by radiological studies. Among them, one responded to conservative treatment while in the other, a JJ-stent was inserted. Two more patients had to be readmitted within one week of discharge because of continuous pain abdomen. Among them also, one responded well to conservative treatment while a JJ-stent was inserted in the other. Stone clearance was achieved in the entire study group by the end of 12 weeks either following pneumatic lithotripsy alone or with the additional procedures. Approximately 76% of patients were stone-free by the end of first week whereas the percentage rose to about 92% by the end of second week. However, 100% stone clearance was achieved by the end of 12 weeks in all patients.

Table 1: Stone size versus lithotripsy time

Stone size:	Number	Percentage: (%)	Lithotripsy time (range):
≤5 mm	8	8.7	10-22 min
6-10 mm	62	67.4	12-23 min
11-20 mm	20	21.7	12-32 min
>20 mm	2	2.2	15-39 min
Total:	**92**	**100.0**	Min -10 min /max time -39 min

Table 2: Site and side of calculi in the ureter

Side	Number	Percentage	Site	Number	Percentage
Right	45	48.9	Upper third	14	15.2
Left	47	51.1	Middle third	26	28.3
Total	92	100	Lower third	52	56.5

Table 3: Site of the stone versus Fragmentation and migration of the stone

Site of calculi:	Complete fragmentation:	stone migration:	Total:
Lower 1/3 ureter	46 (88.5%)	7 (11.5%)	53
Middle 1/3 ureter	20 (76.9%)	5 (23.1%)	25
Upper 1/3 ureter	8 (57.1%)	6 (42.9%)	14
Total:	**74 (80.43%)**	**18(19.56%)**	**92**

Table 4: Preoperative complications

Intraoperative complications	Number(No.)	Percentage (%)
Upward stone migration	18	19.5
Minor mucosal tear	5	5.4
Avulsion of ureter	1	1.1
Total	**24**	**26.1**

Table 5: Postoperative complications

Post-operative complications	Number(No.)	Percentage (%)
Urosepsis	11	52.17
Post-operative pain	8	34.78
Macroscopic haematuria	4	17.39
Total	**23**	**100**

Table 6: Ancillary procedures required after stone fragmentation

Ancillary procedures	Number(No.)	Percentage (%)
JJ stenting	8	8.69
ESWL	7	7.60
JJ stenting/ ESWL	3	3.2
Open surgery	1	1.08
Total:	**19**	**20.65**

Fig 1: Equipments for the Ureterorenoscopy

Fig 2: Ureterorenoscopy on progress

Discussion

Improved technology has revolutionized the management of urinary stones. The advent of semi-rigid, flexible and narrow-calibre ureteroscopes have expanded minimally invasive options in addition to conventional open surgical procedures. Among the various methods of ureteroscopic techniques, the pneumatic lithotripsy has gained worldwide popularity owing to its low cost and high degree of effectiveness.

In the present study, 70.7% underwent the procedure under general anaesthesia while 17.4 % underwent the same under spinal anaesthesia. Due to high expenditure of GA or patient refusal, 8.7 % of them opted for caudal anaesthesia while 3.3% underwent the procedure under intravenous sedation. Caudal route of anaesthesia and intravenous sedation were given only in those cases that had stone in the vesico-ureteric junction (VUJ) where we can anticipate a quick and safe removal.

Of course, performing the procedure without general anaesthesia has advantages; it avoids anaesthetic hazards and reduces procedural costs. However, in many patients in whom the procedure was initiated other routes of anaesthesia, they had to be converted into general anaesthesia owing to failure in achieving substantial pain control. We noticed that the time taken for the procedure varied depending on factors including the size of stone and the site of stone. In general, lithotripsy time tends to increase proportionately with the size of stone as shown. It also varies with the nature of the stone and greater time is taken to break harder monohydrate stones[7].

As it is known, none of the procedures for removal of ureteric stones are yet immune to complications. We faced complications in 51% of our patients. Though it sounds alarming, it mainly includes stone migration into the kidney (19.56%) and minor complications. There was only one major complication directly related to pneumatic lithotripsy, in the form of avulsion of ureter. All the complications were tackled successfully in the end. We didn't have any mortality or unmanageable morbidity related to the procedure. A similar study by SanaUllah et al had an overall complication rate of 25%[8].

Aridogan et al [9] had reported 3.5% mucosal injuries and post-operative macroscopic haematuria in 7.3% of patients. In the present study, 4.34 % had gross haematuria lasting for more than 48 hours, however, none of them required any intervention or blood transfusion; it was controlled just by conservative approach and drinking plenty of water.

Conclusion and recommendations

Pneumatic lithotripsy, due to its high rate of successful stone fragmentation, which is particularly true in the lower and middle third of ureter, is a reliable form of treatment for management of ureteric calculi. Though it can give rise to a large number of complications if meticulous procedure and patient selection is not done, major complications are minimal. Other complications such as upward migration of stones and sepsis can be reduced by proper selection of cases and adequate precautions. Though the present study did not perform a biochemical analysis of stones, other studies have found that pneumatic lithotripsy can fragment all ureteric stones including hard monohydrate stones. Owing to its rapid fragmentation capability, short anaesthesia exposure, fewer significant post-operative complications, quicker

post-operative recovery, and ultimately, shorter hospital stay make it a cost- effective modality.

A further large study to compare the outcome of pneumatic lithotripsy under general anaesthesia with other types of anaesthesia to validate if general anaesthesia maximises the efficacy of pneumatic lithotripsy, reduces time taken for the procedure and reduces stone migration. A comparative randomized prospective study with various therapeutic modalities for ureteric stones to compare their efficacy is recommended so that the procedure with the least morbidity rates in each urology unit can be selected. In order to maximise the efficacy and minimise complications of pneumatic lithotripsy, patients with ureteric calculi should be cautiously selected. More failure was observed in stones in upper third of ureter, which could have been effectively managed with other modalities like ESWL. To minimise major complications, vigilance is required for early recognition and treatment of ureteric injuries during the procedure. Further studies to evaluate the use of newer devices such as Dretler Stone Cone and Lithovac suction device for minimising upward migration of stone during pneumatic lithotripsy are desirable.

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