Original Article

The Impact of Renal Lower Pole Radiographic Anatomy on the clearance of Stone fragments after Extracorporeal Shock wave Lithotripsy

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ABSTRACT

Objectives: 1. To determine the frequency of clearance of stone fragments after extracorporeal shock wave lithotripsy (ESWL) for isolated lower pole renal calculi. **2**. To compare the average Lower Infundibular diameter and lower infundibulo-pelvic angle (L-IPA) between patients with residual stone fragments and those who become stone free after extracorporeal lithotripsy (ESWL) for isolated lower pole renal calculi.

Study design: Descriptive Study.

Place and Duration of Study: This study was conducted at Department of Urology, Liaquat National Postgraduate Medical Centre, Karachi from June 2006 to June 2010.

Materials and Methods: One Hundred patients of either sex, aged > 14 years with isolated lower pole calculi (LPC) of <20mm undergoing ESWL were included in the study, while patients with lower pole calculi > 20mm, multiple renal calculi, congenitally distorted pelvi-calyceal anatomy, with concomitant Ureteric calculi, with decreased urine output due to renal insufficiency, with Hydronephrosis, with previous pyelo-uretral surgery, who required ancillary procedures e.g. Ureteroscopy, DJ Stent insertion were excluded from the study. The confirmation of stone in lower pole and LPC anatomy (width of the infundibulum and lower infundibulo-pelvic angle) were viewed on the IVU. The Infundibular width was measured as the narrowest point of the infundibulum. The L-IPA was determined in two axes, the ureteropelvic axis and the infundibulo-pelvic axis.

Results: Frequency of clearance of stone fragments after ESWL for lower pole renal calculi was 82%. Average L-IPA was significantly higher in those who become stone free after ESWL than patients with residual stone fragments (79.34 ± 8.33 vs. 64.56 ± 5.53, p<0.001). Average Lower Infundibular diameter was slightly higher in stone free patients after ESWL but not statistically significant (5.02 ± 0.76 vs. 4.89 ± 0.78, p=0.631).

Conclusion: Successful ESWL is sensitive to lower pole anatomical variables especially lower Infundibulo-pelvic angle and preferably first line treatment in patient with a lower pole stone has L-IPA >80 degrees and lower infundibular diameter of >5mm.

Key words: ESWL, Renal Calculi, Lower Infundibulo-pelvic angle.

INTRODUCTION

Renal stone disease is a significant and worldwide health problem. This disease affects about 8% to 15% of the population in Europe and North America.[1] Its prevalence is next to malaria and Schistosomiasis. Morbidity rate due to urinary calculi is 2% to 4%, which is similar to that of diabetes.[2] Pakistan is located within the geographical distribution of stone disease. Urolithiasis is the commonest urological problem in Pakistan. The effected populations mean age group in Pakistan is 40 years.[3] Most of stones are composed primarily of calcium oxalate or, less often, calcium phosphate [4]. Only available medical therapy for stones, which is non invasive, is chemotherapy for uric acid calculi. Alkalization of urine may dissolve and cure the stones. However, there is association of surgery with anesthesia, prolonged hospitalization, long incisions, significant blood loss, post operative pain, wound dehiscence, ugly scars and incisional hernias.

Open surgery has been replaced by effective outpatient treatment, which has revolutionized the management of stone disease.[5] Open surgery is still performed especially for large complicated staghorn calculi[6].

The management of Lower pole Calculi (LPC) has always been controversial. Prior to development of Endourology, open stone surgery was the only modality of treatment. Lower pole nephrectomy was common operative procedure performed for LPC in those days to remove poor functioning lower pole and potential source of recurrent calculi. Since the introduction of ESWL and Percutaneous Nephrolithotomy (PNL), the management of LPC stones has changed.

There is a general consensus that the treatment of lower pole calyceal stones has a poor success rate with ESWL due to various factors, these include stone burden, type of lithotripter, LPC anatomy and body habitus[7]. The anatomy of lower pole of kidney is found to be the most important predictive factor in determining the clearance of fragments.

Various variables of the lower pole anatomical dimensions were proposed to have an affect on the outcome of ESWL. Amongst these variables important are the lower pole Infundibulo-pelvic angle and the Lower Infundibular width. There is other variables also e.g. Stone size, Infundibular length, Infundibular height and number of lower pole minor calyces and these were also analyzed in different studies. In different studies, Stone size is found to have a significant impact on the stone clearance, while there is controversy on the effects of other variables on the clearance.

This theory of anatomical variables of lower pole was initially given by Sampaio and Aragao in 1990, indicated that the stone clearance was greater in patients with a lower Infundibulo-pelvic angel of greater that 90 degrees and the lower Infundibular diameter more than 5 mm but their method did not strictly define which segment of the proximal ureter was used when measuring the angle.[8,9] Later on Elbansay et al[10] determined fixed landmarks for to ensure proper measurement of infundibulo-pelvic angle in IVU and described spatial anatomy of lower pole as a possible factor in stone clearance.

Observation in a Meta analysis by Lingmen[11] and other reports showed lower stone free rate of ESWL for LPC when compared to results of stones in other calyces.

The lower pole infundibulo-pelvic angle was the most significant factor followed by infundibular width in a study by Gupta et al. However, infundibular length was not a statistically significant factor in stone clearance in their study[12].

So by taking measurements of the lower infundibulo-pelvic angle as well as Infundibular width and length, several authors have concluded that an acute infundibulo-pelvic angle and a narrow infundibulum has negative influence on fragment clearance[13]. In other studies however, no such relationship has been demonstrated.[14]

It is less difficult for the lower pole calculi to pass in to the renal pelvis after ESWL in the presence of a wider lower infundibular diameter and wide angle. In the presence of these favorable anatomical factors, the stone fragments will be passed from lower pole by flow of urine as well as by change in the direction of gravity by change in position of the patient.

MATERIALS AND METHODS

Study design: Descriptive Study.

Place of Study: Department of Urology, Liaquat National Postgraduate Medical Centre, Karachi.

Duration of Study: June 2006 to June 2010.

Sample Size: Total 100 patients with isolated lower pole calculi will be included in study.

Sampling technique: Non-probability, convenience sampling.

Sample Selection:

Inclusion criteria: Patients of either sex, aged > 14years, with isolated lower pole calyceal calculi of up to 20mm size undergoing ESWL.

Exclusion criteria: Patients with lower pole calculi more than 20mm. Patients with multiple renal calculi, Distorted pelvi-calyceal anatomy congenitally, Patients with concomitant Ureteric calculi, Patients with decreased urine output due to Renal Insufficiency, Patients with Hydronephrosis, Patients with previous pyelo-ureteral surgery, Patients who required ancillary procedures e.g. Ureteroscopy, DJ Stent insertion.

Data Collection Procedure: Patients of either sex aged ≥ 14 years, with isolated lower polar calyceal calculi up to 20mm, from both indoor and OPD will be included in the study. The confirmation of stone in lower pole and LPC anatomy (width of the infundibulum and lower infundibulo-pelvic angle) will be viewed on the Intravenous Urograms (IVU)[15]. The Infundibular width will be measured as the narrowest point of the infundibulum. The lower infundibulo-pelvic angle will be determined in two axes, the ureteropelvic axis and the infundibulo-pelvic axis. Former is an axis connecting the central point of the pelvis opposite the margins of superior and inferior renal sinuses to the central point of ureter opposite the lower pole of the kidney. Latter is the central axis of the lower pole infundibulum. **(Figures No. 1, 2 & 3).**

The procedure of ESWL was explained to all patients and a written consent was taken from patient or his/her attendants. All patients underwent ESWL on Alpha Compact Dornier echo guided lithotripter. Post procedural follow up will be done after every 15 days by plain X-ray or/and ultrasound. All patients with radio-opaque stones will be followed with plain x-rays; ultrasound will be used for patients with radiolucent stones. After the follow-up period of three months, patients will be divided into two groups depending upon stone clearance status: Group I will consist of stone free patients (or with residual fragments up to 03mm) and Group II of those with residual fragments of more than 3mm. All the related variables like age, sex, stone size, lower infundibulo-pelvic angle, lower Infundibular diameter, will be recorded on Performa.

Statistical Analysis: Statistical analysis was preformed through SPSS version-11.0. Ratio (M: F) was computed to present gender distribution. Continuous response variables like age, stone size, lower Infundibulo-pelvic angle and lower infundibular diameter were presented by Mean ± SD. Frequencies and percentages were computed to present qualitative response variables including co-morbid factors, presenting complaints, site of kidney ultrasound/ IVU, clearance of stone fragments after ESWL. Student's t-test (Unpaired) was applied to compare the average lower infundibular diameter and lower infundibulo-pelvic angle between patients with residual stone fragments and those who become stone free after ESWL.

Figure No. 1: Two axes in measurement of L-IPA

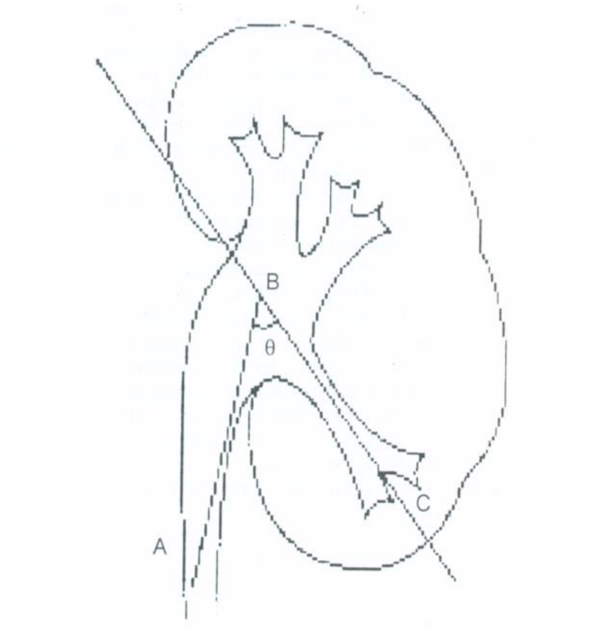


Figure No. 2: Lower Infundibular Diameter

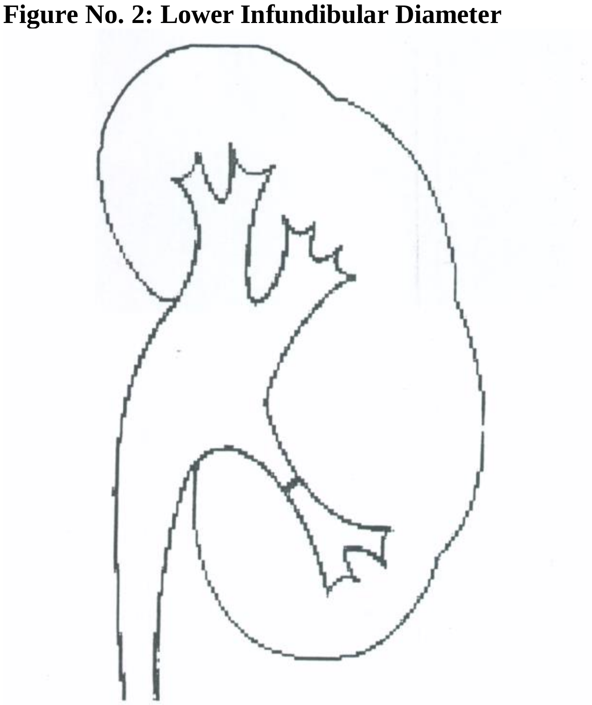


Figure No. 3: IVU measurement of L-IPA

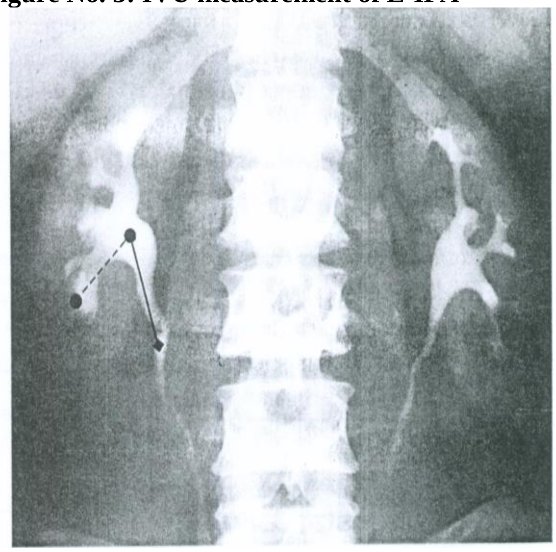


Figure No. 4: Gender distribution:
n = 100 Male, Female = 1.8: 1

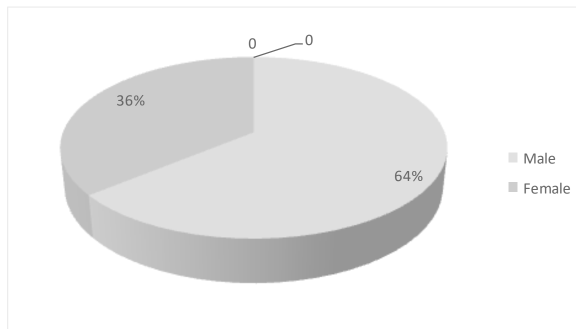
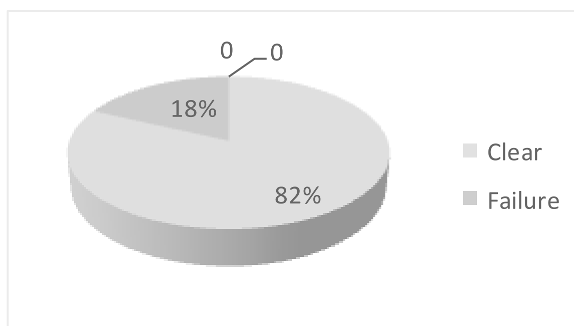


Figure No. 5: Frequency of clearance of stone fragments after Extracorporeal Shock wave Lithotripsy (ESWL) for isolated lower pole renal calculi: n = 100



RESULTS

Out of 100 patients of with isolated lower pole calculi, 64 (64%) were males and 36 (36%) females (M: F = 1.8: 1) as shown in Figure No. 4.

Average age of the patients was 40.46 ± 15.23 (ranging from 15 to 77) years. Fifty percent patients were old between 21 – 40 years.

Figure No. 6: Clearance of Stone fragments on different follow ups: n = 100

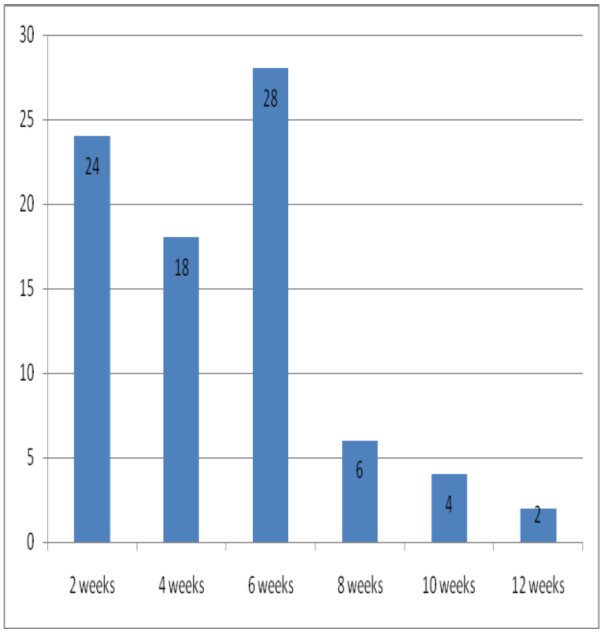
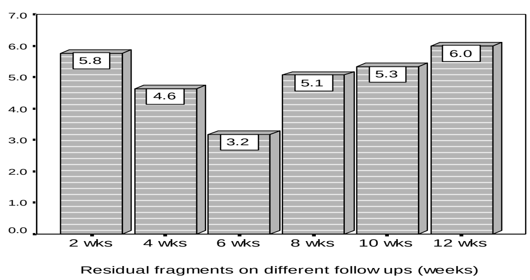


Figure No. 7: Clearance of residual fragments on different follow-ups: n = 100



Total 28 (28%) patients out of 100 were observed having co-morbids. Hypertension was the commonest co-morbid factor that was found in 14 (50%) patients, diabetes mellitus in 12 (42.9%), BPE in 6 (21.4%) and IHD was observed in only 2 (7.1%) patients. (Table No. 1.)

Table No. 1: Co-Morbid Factors: n = 14

Co-morbid factor^	Frequency	Percentage
Hypertension	14	50.0
Diabetes mellitus	12	42.9
BPE	6	21.4
Ischemic heart disease	2	7.1

^ 06 (21.4%) patients had more than one co-morbid factor

Pain was the commonest presenting complaint that was reported by 88 (88%) patients followed by headache in 4 (4%) patients. No complaint was reported by 8 patients. (Table No. 2)

Table No. 2: Presenting complaints: n = 100

Presenting complaint	Frequency
Pain	88%
Headache	4%
No complaint	8%

Ultrasound of right kidney and left kidney were done respectively in 40 (40%) patients and 42 (42%) patients while ultrasound was not done in 18 (18%) patients. Hydronephrosis was not found in any case on ultrasound. The mean stone size on ultrasound was 12.68±4.62. (Table No. 3)

Table No. 3: Ultrasound Findings: n = 100

Investigation	Number of pts
Ultrasound kidney	
▪ Right	40
▪ Left	42
▪ Not done	18
Hydronephrosis on ultrasound	
▪ Yes	0
▪ No	100
Stone size on U/S	12.68±4.62

IVU of right kidney was done in 25 patients and of left kidney also in 25 patients. Hydronephrosis was not found in any case on IVU. The mean stone size on IVU was 12.88±4.39. The mean lower Infundibulo-pelvic angle was 76.68±9.72 and the mean lower infundibular diameter 5.00±0.76. (Table No. 4).

Table No. 4: IVU Findings n= 100

Investigation	Number of patients
IVU kidney done	
▪ Right	50
▪ Left	50
Hydronephrosis on IVU	
▪ Yes	0
▪ No	100
Stone size on IVU	12.88±4.39
Lower Infundibulo-pelvic angle	76.68±9.72
Lower Infundibular diameter	5.00±0.76

Out of 100 patients, frequency of clearance of stone fragments after extracorporeal shock wave lithotripsy (ESWL) for isolated lower pole renal calculi was 82 (82%) while failure of stone fragments was observed in 18 (18%) patients. (Figure No. 5)

Frequency of clearance of stone fragments 2 weeks after ESWL was 24 (24%). Four weeks after ESWL,18 (18%) patients were observed with clearance of stone fragments. After 6 weeks of ESWL, 28 (28%) patients were observed with clearance of stone fragments. After 8 weeks of ESWL, 06 (6%) patients were observed with clearance of stone fragments. Later on, 04 (4%) patients after 10 weeks and 02 (2%) patient after 12 weeks of ESWL were observed stone free. (Figure No. 6)

Table No. 5: Comparison of the average Lower Infundibular Diameter and Lower Infundibulo-pelvic angle between patients with residual stone fragments and those who become stone free after Extracorporeal Lithotripsy (ESWL): n = 100

Variables	Clearance of stone		p-value
	Clearance n = 82	Failure n = 18	
Lower Infundibulo-pelvic angle	79.34 ± 8.33*	64.56 ± 5.53	<0.001
Lower infundibular diameter	5.02 ± 0.76	4.89 ± 0.78	0.631

Key: Values given in columns 2 & 3 are Mean ± SD

Mean residual fragments, two weeks after ESWL was 5.8 ± 3.9, four weeks after ESWL was 4.6 ± 2.9, six weeks after ESWL was 3.2 ± 3.3, eight weeks after ESWL was 5.1 ± 3.1, ten weeks after ESWL was 5.3 ± 3.03 and twelve weeks after ESWL the mean residual fragments was 6 ± 2.7. (Figure No. 7)

Average lower Infundibulo-pelvic angle was significantly higher in those who become stone free after ESWL than patients with residual stone fragments (79.34 ± 8.33 vs. 64.56 ± 5.53, p<0.001). Average lower infundibular diameter was slightly higher in those who become stone free after ESWL than patients with residual stone fragments but not statistically significant (5.02 ± 0.76 vs. 4.89 ± 0.78, p=0.631). (Table No. 5)

DISCUSSION

The principal finding of my study shows that the frequency of stone clearance from lower pole after ESWL was in 82 % of patients. The failure was in 18% of patients. The average L-IPA was significantly higher in those who become stone free than patients with residual stone fragments (79.34 ± 8.33 vs. 64.56 ± 5.53, p<0.001). Average lower infundibular diameter was slightly higher in those who become stone free after ESWL than patients with residual stone fragments but not statistically significant (5.02 ± 0.76 vs. 4.89 ± 0.78, p=0.631).

After the original idea of L-IPA in the resin cast of collecting system given by Sampaio and Aragao, Sabins et al subsequently applied this method to IVU but due to ill defined radiological landmarks, there results did not become reproducible.

Elbansay et al reported residual stones in 64% of the patients with an L-IPA of <90 degrees, lower infundibular width <5mm and lower Infundibular length >25mm; and only 12% in those with IPA of >90%, infundibular width of >5mm and lower Infundibular length of <25mm.

Keely et al [16] showed that if L-IPA is >100 degrees stone clearance rate was 66% while in <100 degrees it is 34%, concluding the significant effect of L-IPA.

In my study, I used the method of Elbansay et al because it depends on the fixed points and hence provides more consequent landmarks for measurement, easily reproducible and it holds valid for both intra-renal as well as extra-renal pelves. I found comparable results of stone clearance of 82 with average L-IPA of around 80 degrees and infundibular diameter of 5mm.

Gupta et al[17] demonstrated L-IPA of greater than 90 degrees was predictive of successful SWL, demonstrating 75% clearance rates compared with 23% for angles less than 90 degrees.

On the other hand some authors don't found a significant impact of L-IPA and infundibular diameter on stone clearance even after three months follow up[18].

Ather MH et al [19] did not find significant effect of L-IPA and infundibular width on the fragment clearance. They concluded that there may be increased shock wave requirement in patients with acute L-IPA and narrow infundibulum, but this was also not statistically significant.

In almost all studies, no demographic or gender distribution is described and in my study, majority were male patients between 21 to 40 years of age. No significant demographic impact on stone clearance was noted.

In my study I found the L-IPA, a significant variable in determining the outcome of ESWL while lower infundibular diameter does not. But because of small number of patients in this study it is difficult to obtain statistically significant results due to small variations in the measurements of lower pole anatomy especially the infundibular diameter. So a large sample study is recommended for more precise results.

The lower infundibulo-pelvic angle is one of the most important variables of lower pole anatomy that can predict the outcome of ESWL and in patients with L-IPA less than 80 degrees or calculi of more than 2cm, other treatment options should be considered e.g. PNL or Pyelolithotomy.

As far as other lower pole anatomical variables are concerned, the stone burden and lower infundibular length are found significant in different studies. In my study I found some short comings and difficulties e.g.:

- After each session of ESWL the follow up after two weeks was often missed by the patient side.
- While measuring the L-IPA and infundibular diameter, the exposure of IVU film should be nearly 100% because if the X-ray size is concise, as generally done to fit four exposures in one film, it is difficult to measure the variable especially the infundibular diameter. So I the radiologists are always required for a full film of 20 minutes

duration in IVU (or if sometimes it was not possible), I measured the variables directly from the monitor screen showing the full exposure.

- Now a day there is trend of un-enhanced CT KUB instead of IVU for the evaluation of Renal Calculi especially in patients with radiolucent calculi and Azotemia. So patients with LPC undergoing ESWL, in whom CT KUB was done, could not include in the study.

Some corporations that are providing medical facilities to their employees may not approve ESWL expenditure at our institute – offering them open surgical procedures.

CONCLUSION

Results of my study demonstrate that:

- The frequency of stone clearance was 82 % (41 patients), while failure was in 18 % (09 patients)
- Male predominance was observed.
- Higher average L-IPA was in stone free patients.

Insignificant difference in lower infundibular diameter in stone free and in patients with residual stones.

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