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RADIOGRAPHIC ANATOMICAL INSIGHTS INTO MECHANISM OF LOWER CALYCEAL STONE EVACUATION FOLLOWING ESWL

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Abstract: This study was aimed to elucidate whether there is significant relationship between the lower calyceal anatomy and stone evacuation following extracorporeal shock wave lithotripsy(ESWL). From April 1995 to November 1999, 145 patients with lower caliceal stones underwent ESWL with Storz Modulith SL20 lithotriptor. The pelvicalyecal angle, lower pole infundibular length and width, and lower pole calyceal pattern of the stone-bearing calyx were measured on pre-ESWL intravenous urograms. Abdominal plain film and ultrasonography taken of all patients at the 3-month followup showed that the overall stone-free rate was 65% after 3 months. The stone-free rate was significantly correlated to the radiographic anatomical factor, 94% in patients with a pelvicalyceal angle of 90 degrees or greater, 57% in those with less than 90 degrees pelvicalyceal angle; 80% in those with infundibular length of 30 mm or less, 59% in those with infundibular length greater than 30 mm; 73% in those with infundibular width greater than 4 mm, 48% in those with infundibular width of 4 mm or less; 85% in those with a simple calyceal pattern and 41% in those with a complex one. These findings suggest that the 4 radiographic anatomical factors of the lower pole calyx(pelvicalyceal angle, infundibular length and width and calyceal pattern) play an important role in stone evacuation after ESWL. Pelvicalyceal angle of 90 degrees or greater, infundibular length of 30 mm or less and width greater than 4 mm, and simple calyceal pattern are respectively noted to relate to an improved stone-free status. In contrast, an acute pelvicalyceal angle, long infundibular length and narrow infundibular width and complex calyceal pattern are individually unfavorable factors for stone emptying following ESWL.

Key words: extracorporeal shock wave lithotripsy, kidney, lower calyx, renal calculi
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INTRODUCTION

Since its clinical introduction, extracorporeal shock wave lithotripsy (ESWL) has maintained an important role in the management of urinary calculi. The success of this therapeutic procedure depends on the effective disintegration and evacuation of stone debris. However, the stone clearance rate differs for renal calculi at different sites, being the lowest for lower pole calyceal calculi after ESWL(Graff et al., 1988). The low clearance rate for lower calyceal stones is more a problem of debris retention rather than stone fragmentation (Sampaio and Aragao, 1992, 1994). The reason for fragment retention in the lower calyx after ESWL remains unknown and is an area of recent interest. The present study was aimed to find out any relationship between the lower calyceal anatomy (pelvicalyceal angle, infundibular length and width as well as calyceal pattern) and the clearance of fragments following ESWL.

METHODS

Between April 1995 and November 1999, 145 patients with lower calyceal calculi (58 female and 87 male patients) who underwent intravenous urography (IVU) preoperatively were treated on the Storz Modulith SL20 lithotriptor in the supine position in our department. Mean patient age was 46.3 years (range 21 to 65 years). The stones were 6 to 21 mm(mean 10.5 mm) at the largest diameter, with 59 left and 86 right stones. Indwelling ureteral stents were placed in 11 patients prior to lithotripsy. Intramuscular Pethidine was used to provide analgesia. Stone imaging was carried out by way of radiography or ultrasonography. Treatments consisted of 500 to 2500 shocks at a maximum power level of 6(corresponding to 17.25kV). This series of 145 patients underwent 174 treatment sessions, giving an overall treatment rate of 1.2; each session lasted 38 minutes on average. Postural drainage with the patient in an opposite lateral position was taken after ESWL, associated with dorsal

percussion to mobilize retained fragments in the lower calices. One day following treatment a plain abdominal film(KUB) and ultrasonography were obtained to assess fragmentation. The stone-free status was evaluated by examining the postoperative radiographs. Follow up after ESWL consisted of KUB and ultrasonography within the first 2 to 4 weeks of treatment followed by additional radiographs and ultrasonography at 3 month intervals. Any evidence of persistent stone debris in the region of the lower calyx, either on KUB or on ultrasonography 3 months after the completion of treatment was defined as stone retention. Ninety-four patients in whom lower calyceal stones were completely cleared after 3 months comprised the stone-free group and 51 who had stone retention after 3 months comprised the not stone-free group.

Radiographic anatomical factors were determined on pre-ESWL IVU as described by Sampaio et al. (Sampaio and Aragao, 1994; Sabnis et al., 1997; Elbahnasy et al., 1998), including pelvicalyceal angle, infundibular length and width, and calyceal pattern (Fig.1 and Fig.2). To measure the pelvicalyceal angle a line was drawn connecting the central point of the renal pelvis opposite the interior margins of the upper and lower pole of the kidney to the central point of the ureter opposite the lower kidney pole(ureteropelvic axis). The inner angle formed at the intersection of the ureteropelvic axis and central axis of the lower pole infundibulum was taken as the pelvicalyceal angle. Infundibular length was measured as the distance from the most distal point at the bottom of the calyx containing stone to a midpoint of the lower lip of the renal pelvis. Infundibular width was measured at the narrowest point along the lower pole infundibular axis. The lower pole calyceal pattern was considered simple, if minor calyces opened into a single major calyx, which then joined the renal pelvis; and considered complex if multiple calyces either fused with each other and joined the major calyx, or opened directly into the renal pelvis, outpouching from the minor calyx, or if there were any additional small calyces opening directly into the pelvis.

Data were expressed as median(range). Statistical analyses were made using chi-square test and Mann-Whitney test

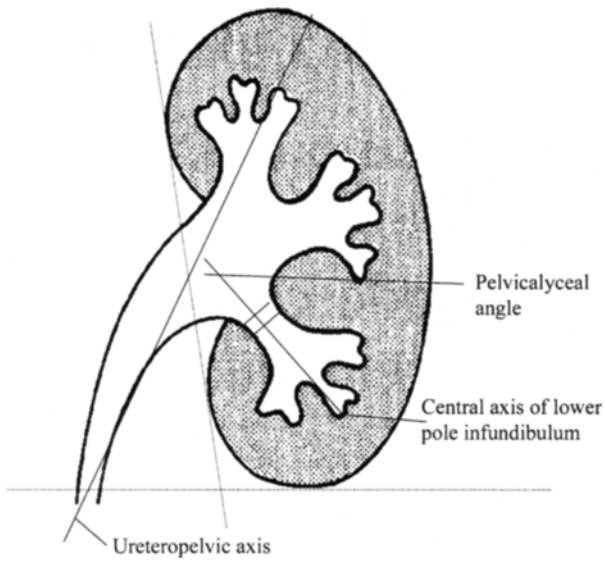

Fig.1 Measurement of pelvicalyceal angle.

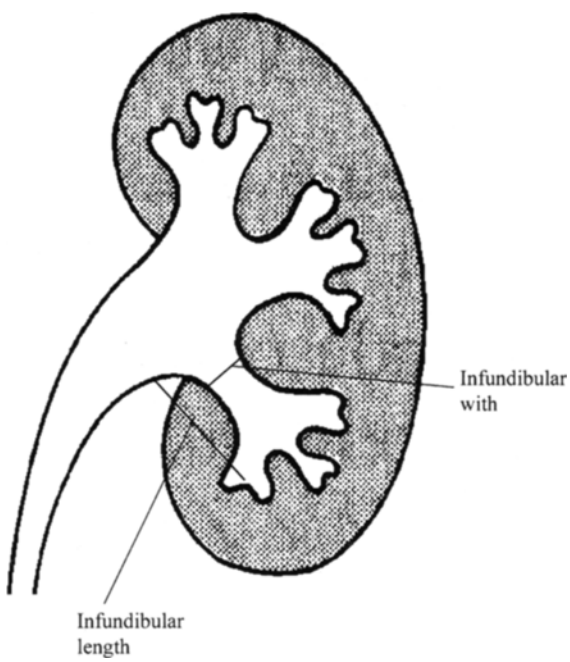

Fig.2 Measurements of infundibular length and width

RESULTS

All patients showed good renal function on pre-ESWL IVU. One hundred twenty-six patients required a single treatment only. There

were few serious complications. However, 1 patient developed fever requiring intravenous antibiotics and 1 patient had renal colic. Hematuria occurred in most patients and was self-limited, lasting less than 24 hours. Ninety-four patients were stone-free and 51 had residual stones 3 months after ESWL. The overall stone-free rate at 3 months was 65%.

The pelvicalyceal angle was 37 to 119 degrees, with 21% of the patients having a pelvicalyceal angle of 90 degrees or greater. The infundibular length was 25 to 47 mm, with 27% of the patients having a length of 30 mm or less. The infundibular width was 3 to 13 mm, with 67% of the patients having a width of greater than 4 mm. 55% of the patients had a simple, and 45% a complex, lower pole calyceal pattern.

The influence of pelvicalyceal angle, infundibular length and width, and lower pole ca-

Table 1 Lower pole radiographic anatomical factors versus stone-free status at 3-month followup in 145 patients with lower calyceal calculi

Lower pole radiographic anatomical factors	Stone-free	Not stone-free group ($n = 94$)	P value group ($n = 51$)
Pelvicalyceal angle	81.8	62.1	< 0.001
(degrees)	(47 ~ 119)	(37 ~ 97)	(Mann-Whitney test)
Infundibular length	31.5	38.6	< 0.001
(mm)	(25 ~ 43)	(29 ~ 47)	(Mann-Whitney test)
Infundibular width	8.8	4.7	0.001
(mm)	(3 ~ 13)	(3 ~ 11)	(Mann-Whitney test)
Calyceal pattern, n(%)			
Simple	67(71)	12(24)	< 0.001 (Chi-square test)
Complex	27(29)	39(76)	< 0.001 (Chi-square test)

Table 2 Impact of lower pole radiographic anatomical factors on stone-free rate following ESWL

Lower pole radiographic anatomical factors	Numbers of patients (n)	Stone-free rate (%)	P value (chi-square test)
Pelvicalyceal angle(degrees)			
90 or greater	31	94	0.003
Less than 90	114	57	
Infundibular length(mm)			
30 or less	39	80	0.011
Greater than 30	106	59	
Infundibular width(mm)			
Greater than 4	97	73	0.03
4 or less	48	48	
Calyceal pattern			
Simple	79	85	< 0.001
Complex	66	41	

lyceal pattern on stone-free status is shown in Tables 1 and 2. The pelvicalyceal angle was significantly larger in the stone-free patients(81.8 versus 62.1 degrees, $P < 0.001$). The infundibular length was significantly shorter in stone-free cases than in those with residual fragments(31.5 versus 38.6 mm, $P < 0.001$). The infundibular width in stone-free patients was significantly greater than that in patients with residual stones (8.8 versus 4.7 mm, $P = 0.001$).

Patients with simple calyceal pattern in the stone-free group were more than those in the not stone-free group ($P < 0.001$). The stone-free rate was significantly related to anatomical measurement, 94% in patients with pelvicalyceal angle 90 degrees or greater, 57% in patients with pelvicalyceal angle of less than 90 degrees ($P = 0.003$); 80% in those with infundibular length of 30 mm or less, 59% in those with infundibular length of greater than 30 mm ($P = 0.011$); 73% in those with infundibular width of greater than 4 mm, 48% in those with infundibular width of 4 mm or less($P = 0.003$); 85% in those with simple calyceal pattern and 41% in those with complex calyceal pattern ($P < 0.001$).

DISCUSSION

Because of its efficacy, efficiency and low morbidity, extracorporeal shock wave lithotripsy has become the method of choice for treating almost all urinary calculi. However, stone evacuation following ESWL has been shown to be affected by the stone size, location and chemical composition as well as by kidney anatomy. Cystine calculi, lower calyceal stones, stones larger than 20 mm and hydronephrosis adversely affect the outcome of ESWL. The overall stone-free rate for lower calyceal stones was 58 to 69%, lower than that for upper and middle calyceal stones and renal pelvic calculi (Graff et al., 1988; Sabnis et al., 1997; Elbahnasy et al., 1998). In our study the overall stone-free rate at 3 months was 65%. The low clearance rate for lower calyx calculi is more a problem of retention of debris rather than stone disintegration (Sampaio and Aragao, 1992, 1994).

The reasons for debris retention in the lower calyx after ESWL are unclear. It is most commonly thought that the gravity dependent position of the lower calyx precludes efficient stone passage(Sampaio and Aragao, 1994; Sabnis et al., 1997). Sampaio and Aragao first reported the spatial anatomy of the lower pole as a possible factor in stone passage, determining the lower pole calyceal distribution, infundibular diameter and the angle between lower infundibula and renal pelvis. An acutely oriented infundibulum gave rise to much poorer stone emptying than a lower pole infundibulum with an angle of 90 degrees or greater (1992, 1994). Sabnis et al. showed that there were residual stones in 64% of the patients with a pelvicalyceal angle of less than 90 degrees, in 12% of those with an angle of greater than 90 degrees, in 70% of patients with an infundibular diameter of less than 4 mm, in 16% of those with a diameter of greater than 4 mm, in 78% of those with a complex calyceal pattern and in 12% in those with a simple one (1997). In another study, Elbahnasy et al. reported that infundibulopelvic angle of 90 degrees or greater, and infundibular length of less than 30 mm and width greater than 5 mm are significant favorable factors for stone clearance after ESWL(1998).

In the present study we measured 4 aspects of the spatial anatomy of the lower pole in 145 patients with lower calyceal stones on pre-ESWL IVU, including the pelvicalyceal angle, infundibular length and width, and lower pole calyceal pattern. The stone-free rate at 3 months was significantly correlated to each anatomical factor, 94% in patients with pelvicalyceal angle of 90 degrees or greater, 57% in those with pelvicalyceal angle of less than 90 degrees; 80% in those with infundibular length of 30 mm or less, 59% in those with infundibular length of greater than 30 mm; 73% in those with infundibular width of greater than 4 mm, 48% in those with infundibular width of 4 mm or less; 85% in those with simple calyceal pattern and 41% in those with complex pattern. These data suggest that the 4 anatomical factors play important roles in stone evacuation following ESWL, with a wide pelvicalyceal angle, short infundibular length, broad infundibular width and simple calyceal pattern being significant favorable factors. Thus, the 4 radiographic anatomical factors can be used

to predict the stone clearance after lithotripsy in patients with lower calyceal calculi and select the most appropriate candidates for ESWL.

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