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Comparative Follow-Up of Patients with Acute and Obtuse Infundibulum–Pelvic Angle Submitted to Extracorporeal Shockwave Lithotripsy for Lower Caliceal Stones: Preliminary Report and Proposed Study Design

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ABSTRACT

Nowadays, there is a consensus that the poor success rate of extracorporeal shockwave lithotripsy (SWL) is in the treatment of lower caliceal stones. The gravity-dependent position of the lower-pole calices is postulated to be the main factor hindering the spontaneous passage of stone debris that results from SWL. Nevertheless, we proposed that there are some particular features of the inferior-pole collecting system anatomy that could contribute to fragment retention. We studied the influence of the lower infundibulum–pelvic angle on fragment retention, considering 74 patients submitted to SWL for the treatment of lower-pole nephrolithiasis in a Lithostar Plus machine. At a mean follow-up of 9 months, 75% of the patients presenting an angle of greater than 90° between the lower infundibulum where the stone was located and the renal pelvis became stone-free within 3 months. On the other hand, only 23% of the patients presenting an angle smaller than 90° between the lower infundibulum where the stone was located and the renal pelvis became stone-free during the follow-up. Determination of the angle between the renal pelvis and the infundibulum of the inferior pole calix where the stone is located is very important, because the angle will differ in the same kidney, depending on stone location. Although preliminary and based on a small series of patients, our data suggest that an acute pelvic–lower pole infundibular angle hinders the spontaneous discharge of fragments after SWL. Also, use of the proposed technique of pelvic–lower pole infundibular angle measurement will be important for unifying angle evaluation by other investigators.

INTRODUCTION

BECAUSE OF ITS NONINVASIVE NATURE, low complication rate, and high patient acceptance, extracorporeal shockwave lithotripsy (SWL) is usually the method of choice for the treatment of kidney stones, including those located in the calices. Nevertheless, among other factors, the success of SWL depends on the size, composition, and location of the stone within the kidney.[1–3] Nowadays, there is a consensus that the poor success rate is in the treatment of lower caliceal stones. At a mean follow-up of 19 months after SWL, higher stone-free rates were reported for calculi in upper calices (78%), middle calices (76%), and renal pelvis (84%) than for calculi in inferior calices (58%).[4] Other studies likewise showed that stone location affects the rate of success after SWL and confirmed that calculi in lower calices clear less well than those in upper or middle calices or the renal pelvis.[5–13]

The gravity-dependent position of the lower-pole calices is postulated to be the main factor hindering the spontaneous passage of stone debris that results from SWL.[4–7,9,11,12] Although investigators agree that the discharge of fragments is negatively affected by the gravity, it remains unknown why some patients clear stones in lower calices well and others do not. Therefore, it is necessary to clarify the other factors involved. Previously,

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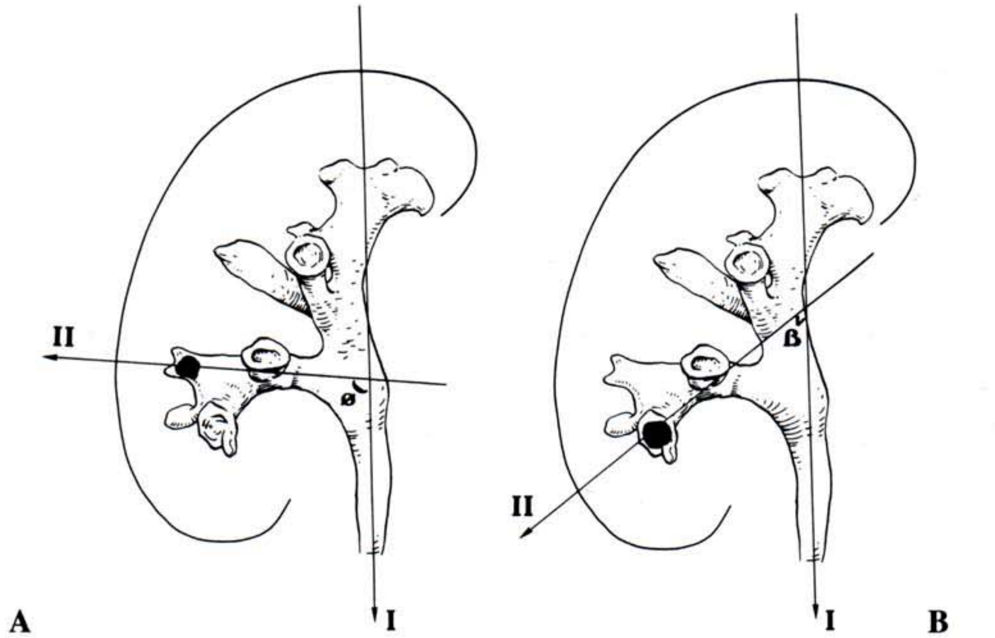

FIG. 1. Anterior view of right pelviocaliceal system. A. Stone located in inferior pole calix whose neck follows axis of main inferior infundibulum. I = first line linking central axis of superior ureter with central axis of ureteropelvic junction. II = second line traced through central axis of main inferior infundibulum. In this case, infundibulum–pelvic angle (ϕ) at intersection of lines I and II measures 95°. B. Stone located in minor inferior-pole calix whose infundibulum (neck) does not follow axis of main inferior infundibulum. I = first line linking central axis of superior ureter with central axis of ureteropelvic junction. II = second line traced considering central axis of infundibulum (neck) where calculus is located. In this case, infundibulum–pelvic angle (β) at intersection of lines I and II measures 53°.

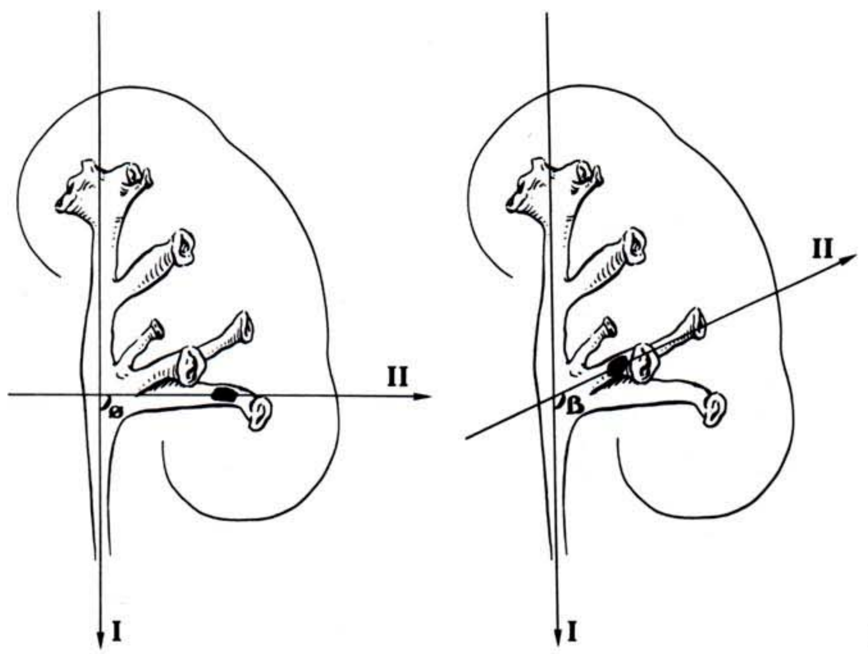

FIG. 2. Anterior view of left pelviocaliceal system. I and II are as in Figure 1. A. Stone located in inferior pole calix whose neck follows the axis of the main inferior infundibulum. Infundibulum–pelvic angle (ϕ) at intersection of lines I and II measures 89°. B. Stone located in minor inferior-pole calix whose infundibulum (neck) does not follow axis of main inferior infundibulum. In this case, the infundibulum–pelvic angle (β) at intersection of lines I and II measures 114°.

we proposed that there are some particular features of the inferior-pole collecting system anatomy that could be important in fragment retention after SWL. The anatomic features proposed were infundibular diameter, the spatial distribution of the lower calices, and the angle formed between the lower infundibulum and the renal pelvis.[14–16]

For this work, we studied the influence of the lower infundibulum–pelvic angle in fragment retention, considering patients submitted to SWL for treatment of lower caliceal stones. Also, we propose a technique of pelvic–lower pole infundibular angle measurement to be applied in patients with lower-pole caliceal stones submitted to SWL.

MATERIALS AND METHODS

Anatomic Background

We reviewed 146 three-dimensional polyester resin corrosion endocasts of the kidney collecting system obtained by the technique described in previous papers.[13,17] Because polyester resin polymerizes by addition of a catalyst, there is no shrinkage on setting, enabling the measurements of the angles that existed *in vivo*.[13,17] In the endocasts, the anatomy was analyzed considering the angle formed between the main lower infundibulum and the renal pelvis.

Patients

We prospectively analyzed 74 patients submitted to SWL for treatment of lower-pole nephrolithiasis in a Lithostar Plus machine. The patients were divided into two groups according to the lower infundibulum–pelvic angle. The angle was measured considering the calix where the stone was located, as described in the next paragraph. We included only patients with a single stone in the lower pole. The stone size ranged from 7 to 25 mm (mean 14.6 mm). The mean number of shockwaves per treatment was 4600, and the mean energy applied was 16.98 kV.

Infundibulum–Pelvic Angle Measurement

For evaluation of the angle, two lines must be drawn. The first line links the central axis of the superior ureter with the central axis of the ureteropelvic region (Figs. 1 through 4). To draw the second line, the site where the calculus is located is considered. If the calculus is located in a calix whose neck follows the axis of the main inferior infundibulum, the second line is drawn through the central axis of this infundibulum (Figs. 1A, 2A, 3A, and 4A). However, if the calculus is located in a minor calix whose infundibular neck does not follow the axis of the main inferior infundibulum, the second line is drawn through the central axis of the infundibulum (neck) of the calix where the calculus is located (Figs. 1B, 2B, 3B, and 4B). After the first and second lines have been drawn, the angle is measured in the intersection of the lines using a mathematical protractor.

RESULTS

In 52 patients, an angle of >90° (obtuse angle) was formed between the inferior-pole calix where the stone was located and the renal pelvis. In the other 22 patients, the angle was <90° (acute angle).

The follow-up of the patients, ranging from 3 to 12 months (mean 9 months), showed the following results. In the group of

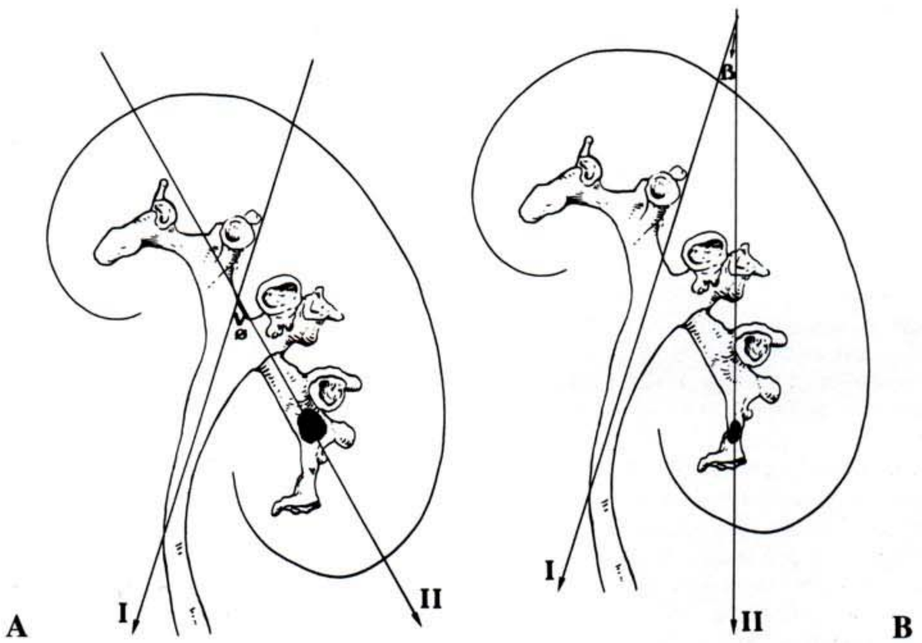

FIG. 3. Anterior view of left pelviocaliceal system. I and II are as in Figure 1. A. Stone located in inferior pole calix whose neck follows axis of main inferior infundibulum. Infundibulum–pelvic angle (ϕ) at intersection of lines I and II measures 47°. B. Stone located in minor inferior-pole calix whose infundibulum (neck) does not follow axis of main inferior infundibulum. In this case, infundibulum–pelvic angle (β) at intersection of lines I and II measures 17°.

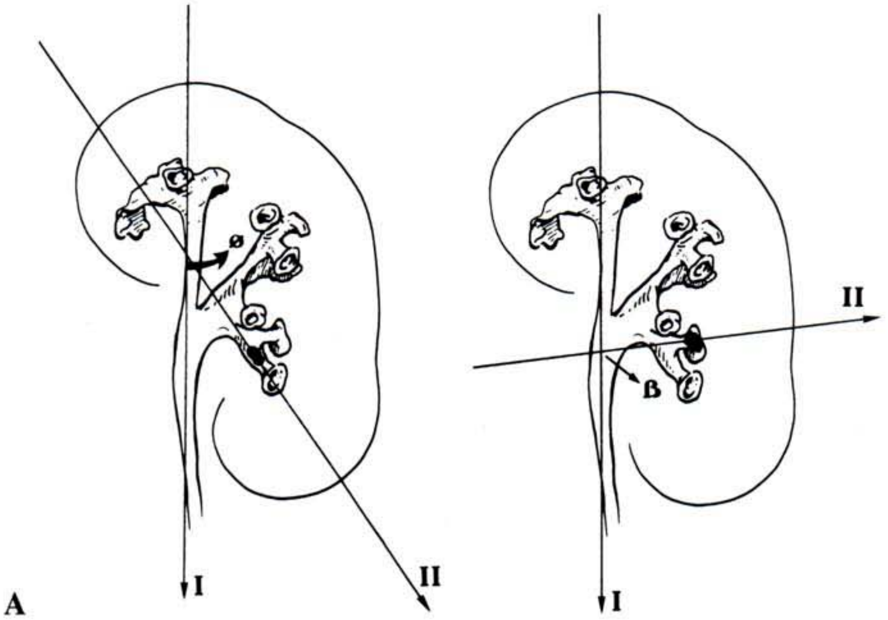

FIG. 4. Anterior view of left pelviocaliceal system. I and II are as in Figure I. A. Stone located in inferior pole calix whose neck follows axis of the main inferior infundibulum. Infundibulum–pelvic angle (ϕ) at intersection of lines I and II measures 35°. B. Stone located in minor inferior-pole calix whose infundibulum (neck) does not follow axis of main inferior infundibulum. In this case, infundibulum–pelvic angle (β) at intersection of lines I and II measures 97°.

patients presenting an angle of >90° between the lower infundibulum where the stone was located and the renal pelvis, 39 patients (75% of the group) became stone free in 3 months. On the other hand, in the group of patients presenting an angle of <90°, only 5 patients (23% of the group) became stone free during the follow-up. Applying the χ^2 test, we confirmed that this difference is statistically significant (level of significance of 1%).

If, after treatment or during the follow-up, the stone moved to another lower-pole calix, altering the lower infundibulum–pelvic angle initially determined, the patient was withdrawn from the protocol.

DISCUSSION

Fragment retention after SWL is a matter of concern, because difficulties in passage of the stone debris might lead to pain, hydronephrosis, and urosepsis, increasing the need for additional urologic procedures. Moreover, residual debris in the collecting system will act as a nidus for future stone formation and recurrent urinary tract infection.[3,6,8,18,19]

The higher rate of residual calculi after SWL for lower caliceal stones, irrespective of their size, is a consistent finding by various investigators.[2–13] Besides, renal calculi in a lower pole calix represent a significant percentage (24% to 44%) of the population that need treatment for urinary stone disease.[9,18,20] Therefore, at present, this is one of the most important topics of interest in SWL. In efforts to improve the success rate, different adjuncts to SWL have been proposed, such an inversion therapy (patients in a head-down position), direct irrigation of the lower calices during SWL, forced diuresis with percussion of the flank area, and placement of the patient in a Trendelenburg position during and after the procedure. Nevertheless, the results of clinical trials showed that these measures were not economically feasible or were not a useful adjunct to SWL for treatment of lower pole stones.[3,7,9,11,12] Recently, Chen and Streem[21] reported a stone-free rate of 48% at 1-month follow-up and 53.3% at long-term follow-up (17.5 months) for lower caliceal stones with a median stone burden of 88 mm^2 (4–625 mm^2). These authors proposed SWL for lower pole calculi of <2 cm^2; nevertheless, they did not take into account the infundibulum–pelvic angle.

The reasons for delayed, insufficient, or absent discharge of residual lower-pole fragments over long periods remain unknown.[6] Undoubtedly, the gravity-dependent position of the lower calices plays a role; nevertheless, other factors may also be important.

We are investigating some particular features of the inferior-pole collecting system anatomy and their importance in the evacuation of stone fragments. For the present work, we evaluated the angle between the infundibulum of the lower pole calix where the stone was located and the renal pelvis prior to SWL. Our initial results showed that 75% of the patients with an angle >90° achieved a stone-free state in 3 months, whereas only 23% of the patients presenting an angle of <90° were stone free during the follow-up.[22] Applying the χ^2 test, we confirmed these differences to be statistically significant. Although preliminary and based on a small series of patients, our data suggested that an acute angle formed between the calix where the stone is located and the renal pelvis may hinder the spontaneous discharge of fragments after SWL.

Determination of the infundibulum–pelvic angle considering the inferior calix where the stone is located is very important, because the angle will differ in the same kidney, depending on stone location. Therefore, in one situation, the angle will be

>90° (95°; see Fig. 1A), and in the same kidney, if the stone is located in another calix, the pelvic–lower pole infundibular angle will be <90° (53°; see Fig. 1B). In the same way, an infundibulum–pelvic angle will be acute when the stone is located in a more dependent calix (35°; See Fig. 4A), and in the same lower pole collecting system, the angle will be obtuse (97°; see Fig. 4B) if the stone is located in another calix.

CONCLUSIONS

Although our initial clinical trial included a small number of patients, our data showed that an acute angle between the calix where the stone is located and the renal pelvis may be a significant negative factor in the rate of success after SWL for stones located in the lower pole. Also, we believe that the technique of pelvic–lower pole infundibular angle measurements proposed in the present study will be very important for unifying angle evaluation by other investigators. Further clinical trials taking into account the infundibulum–pelvic angle considering the inferior pole calix where the stone is located will better clarify the relation between the angle and the results of SWL for lower pole calculi.

REFERENCES

1. Smith AD: Stone management in the '90s. AUA Today November 1990;3:16
2. Siegel YI, Lingeman JE, Steele B: The management of lower pole nephrolithiasis: meta-analysis (abstract 21). J Urol 1993;149:219A
3. Lee CK, Moldwin RM: Treatment of lower calyceal stones. In: Smith AD (ed.): Controversies in Endourology. Philadelphia: WB Saunders, 1995, pp 107–111
4. Graff J, Diederichs W, Schulze H: Long-term follow-up in 1,003 ESWL patients. J Urol 1988;140:479
5. McCullough DL: Extracorporeal shock wave lithotripsy and residual stone fragments in lower calices (letter). J Urol 1989;141:140
6. McDougall EM, Denstedt JD, Brown RD, et al: Comparison of extracorporeal shock wave lithotripsy and percutaneous nephrolithotomy for the treatment of renal calculi in lower pole calices. J Endourol 1989;3:265
7. Brownlee N, Foster M, Griffith DP, et al: Controlled inversion therapy: an adjunct to the elimination of gravity-dependent fragments following extracorporeal shock wave lithotripsy. J Urol 1990; 143:1096
8. Lingeman JE, Coury TA, Newman DM, et al: Comparison of results and morbidity of percutaneous nephrostolithotomy and extracorporeal shock wave lithotripsy. J Urol 1987;138:485
9. Nicely ER, Maggio MI, Kuhn EJ: The use of a cystoscopically placed cobra catheter for directed irrigation of lower pole caliceal stones during extracorporeal shock wave lithotripsy. J Urol 1992;148:1036
10. Lingeman JE, Siegel YI, Steele B: Percutaneous nephrosto-lithotomy for the management of nonstaghorn lower pole nephrolithiasis (abstract 408). J Urol 1993;149:315A
11. Tolon M, Miroglu H, Tolon J, et al: A report on extracorporeal shock wave lithotripsy results on 1,569 renal units in an outpatient clinic. J Urol 1991;145:695
12. Netto NR, Claro JFA, Cortado PL, et al: Adjunct controlled inversion therapy following extracorporeal shock wave lithotripsy for lower pole caliceal stones. J Urol 1991;146:953
13. Lingeman JE, Siegel YI, Steele B, et al: Management of lower pole nephrolithiasis: a critical analysis. J Urol 1994;151:663
14. Sampaio FJB, Aragão AHM: Inferior pole collecting system anatomy: its probable role in extracorporeal shock wave lithotripsy. J Urol 1992;147:322
15. Sampaio FJB: Spatial anatomy of the lower calices: importance in extracorporeal shock wave lithotripsy. In: Renal Anatomy Applied to Urology, Endourology, and Interventional Radiology. New York: Thieme Medical Publishers, 1993, pp 16–22
16. Sampaio FJB, Aragão AHM: Limitations of extracorporeal shock wave lithotripsy for lower caliceal stones: anatomic insight. J Endourol 1994;8:241
17. Sampaio FJB, Lacerda CAM: 3-Dimensional and radiologic pelviocaliceal anatomy for endourology. J Urol 1988;140:1352
18. Drach GW, Dretler S, Fair W, et al: Report of the United States Cooperative Study of Extracorporeal Shock Wave Lithotripsy. J Urol 1986;135:1127
19. Streem SB, Yost A, Mascha E: Clinical implications of clinically insignificant stone fragments after extracorporeal shock wave lithotripsy. J Urol 1996;155:1186
20. Rassweiler J, Gumpinger R, Bub P, et al: Wolf Piezolith 2200 versus the modified Dornier HM3: efficacy and range of indications. Eur Urol 1989;16:1
21. Chen RN, Streem SB: Extracorporeal shock wave lithotripsy for lower pole calculi: long term radiographic and clinical outcome. J Urol 1996;156:1572
22. Sampaio FJB, D'Anunciação A, Silva ECG: Comparative follow-up of patients with acute and obtuse infundibulum–pelvic angle submitted to SWL for treatment of lower pole nephrolithiasis (abstract). J Endourol 1995;9(suppl):63

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