

## INFERIOR POLE COLLECTING SYSTEM ANATOMY: ITS PROBABLE ROLE IN EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY

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### ABSTRACT

In addition to the gravity-dependent position, we believe that other particular anatomical features may be important in the retention of stone debris in the lower calices after extracorporeal shock wave lithotripsy (ESWL†). We analyzed the inferior pole collecting system anatomy in 146, 3-dimensional polyester resin corrosion endocasts of the pelvicaliceal system. The inferior pole was drained by multiple calices disposed in 2 rows in 56.8% of the cases and by 1 midline caliceal infundibulum in 43.2%. In 60.3% of the cases there was a lower infundibulum equal to or greater than 4 mm. in diameter and 39.7% had a lower infundibulum smaller than 4 mm. in diameter. In 74.0% of the cases an angle of greater than 90 degrees was formed between the lower infundibulum and the renal pelvis, and in 26.0% the angle was 90 degrees or smaller. We believe that the physician should consider these anatomical features when suggesting ESWL to treat calculi in the lower calices.

KEY WORDS: extracorporeal shockwave lithotripsy; kidney calculi; anatomy; kidney tubules, collecting

After its clinical introduction extracorporeal shock wave lithotripsy (ESWL) rapidly became the method of choice for the treatment of kidney stones.<sup>1,2</sup> ESWL appears to be safe, efficient and cost-effective for the majority of cases. However, stone location affects the degree of achieving a state free of stones. There is a consensus that regardless of size stones in the lower calices treated with ESWL have a poor clearance rate due to the gravity-dependent position of these calices.<sup>3-6</sup> Obviously the gravity-dependent situation of inferior pole calices has an important role in hampering the passage of fragments. Nevertheless, it remains unknown why lower caliceal stones clear well in some patients and others have insufficient or absent discharge of inferior pole fragments for long periods after ESWL. We believe that besides the gravity-dependent position of the lower calices other anatomical features, such as the lower caliceal spatial distribution, the lower infundibula diameters and the angle formed between the lower infundibulum and renal pelvis, may be important in the evacuation of stone fragments. We study the inferior pole collecting system spatial anatomy and discuss its probable role in fragment evacuation after ESWL.

### MATERIAL AND METHODS

The study was based on the analysis of 146, 3-dimensional polyester resin endocasts of the kidney collecting system obtained from 73 fresh adult cadavers of both sexes. The causes of death were not related to the urinary tract. A yellow polyester resin was injected into the ureter to fill the kidney collecting system. Added to the resin was a styrene monomer as a diluent and a methyl ethyl ketone peroxide as a catalyst, according to the proportions and technique described previously.<sup>7-10</sup> After the injected resin had set the kidneys were immersed in hydrochloric acid until total corrosion of the organic matter was achieved and the endocast was obtained. Because polyester resin polymerizes by addition of a catalyst there is no shrinkage on setting, enabling the measurements of diameters and angles as existed in vivo.<sup>7-10</sup> Thus, the endocasts were analyzed con-

sidering the lower caliceal spatial distribution, the lower infundibula diameters, and the angle formed between the lower infundibulum and the renal pelvis.

### RESULTS

*Inferior pole caliceal distribution.* In 83 of 146 casts (56.8%) the inferior pole was drained by multiple calices (3 to 7) disposed in 2 rows (fig. 1). In the remaining 63 casts (43.2%) the inferior pole was drained by 1 midline caliceal infundibulum receiving 2 or 3 fused papillae (fig. 2).

*Infundibular diameter.* In 88 of 146 casts (60.3%) we found inferior pole infundibula equal to or greater than 4 mm. in diameter (fig. 2, A). In the remaining 58 casts (39.7%) the lower calices presented at least 1 infundibulum smaller than 4 mm. in diameter (fig. 1, A).

*Angle between lower infundibula and renal pelvis.* In 108 of 146 casts (74.0%) an angle of greater than 90 degrees was formed between the lower infundibulum and the renal pelvis (fig. 3, A). In the other 38 casts (26.0%) the angle was close to or smaller than 90 degrees (fig. 3, B).

### DISCUSSION

Retention of stone fragments in the lower calices is an important shortcoming of ESWL. Many physicians reported that stone location affects the rate of success after ESWL and agree that calculi in an inferior pole clear less well than calculi in upper or middle calices, or in the renal pelvis.<sup>2-6, 11-13</sup> Our anatomical findings suggest that retention of passable stone fragments (4 mm. or less) in an inferior pole might not only be a consequence of the gravity-dependent position of the lower calices but an association of this dependent position with particular anatomical features of the inferior pole collecting system. In many cases the inferior pole collecting system spatial anatomy appears definitely to be an important factor in the evacuation of stones debris.

In regard to infundibular drainage many physicians affirm that there usually is only 1 caliceal infundibulum draining each pole.<sup>14-17</sup> Nevertheless, we found the inferior pole to be drained by multiple calices arranged in 2 rows in 83 of 146 casts (56.8%, fig. 1, B) and by 1 midline caliceal infundibulum in 63 casts (43.2%, fig. 2, B). It is conceivable that an inferior pole with multiple calices (fig. 1) has poorer drainage and, consequently, less possibility of eliminating stone fragments compared to an

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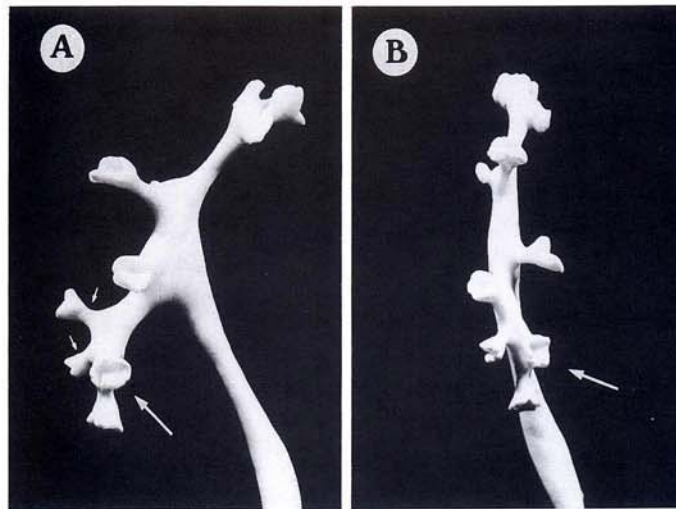


FIG. 1. A, anterior view of pelvicaliceal endocast from right kidney shows inferior pole drained by multiple calices (long arrow). There are calices with infundibula smaller than 4 mm. in diameter (short arrows). B, lateral view of same cast shows calices arranged in 2 rows (arrow), anterior and posterior.

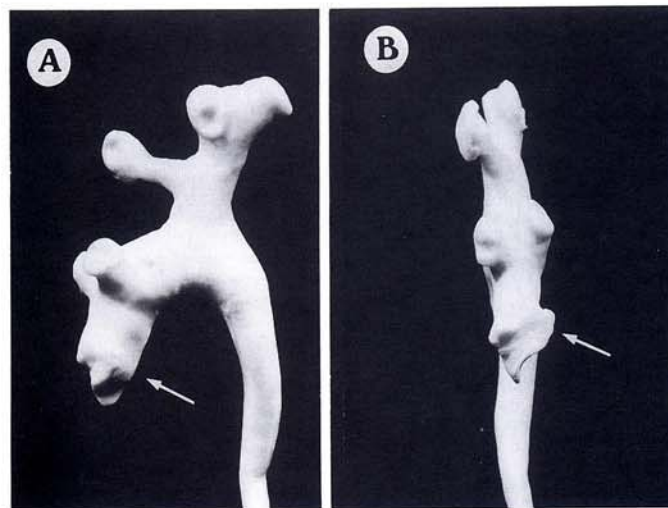


FIG. 2. A, anterior view of pelvicaliceal endocast from right kidney shows inferior pole drained by 1 single midline caliceal infundibulum greater than 4 mm. in diameter (arrow). B, lateral view of same cast shows midline infundibulum receiving fused calices (arrow).

inferior pole drained by only 1 midline caliceal infundibulum receiving fused calices (fig. 2).

In addition, we believe that lower caliceal infundibular diameters may also have an important role in ESWL. Infundibula smaller than 4 mm. in diameter (39.7% of the cases, fig. 1, A) will make the passage of stone fragments after ESWL difficult. On the contrary, a midline infundibulum with suitable diameter (greater than 4 mm.), found in 60.3% of our cases (fig. 2, A), should facilitate the elimination of such fragments. We also believe that the infundibular angle is important in inferior pole drainage. Patients who have an angle of greater than 90 degrees between the lower infundibulum and the renal pelvis (74.0% of our cases, fig. 3, A) should have better drainage and consequently eliminate stone debris more easily than those with an angle close to or smaller than 90 degrees (26.0% of our cases, fig. 3, B). Moreover, the lower calices drained by infundibula that form angles of greater than 90 degrees with the renal pelvis (fig. 3, A) will achieve a gravity-favorable situation (good

drainage) when the patient lies in an opposite lateral position. In these cases after ESWL the physician may advise the patient to sleep in an opposite lateral position to help enhance the elimination of fragments from the lower calices. On the contrary, the lower calices drained by infundibula that form angles close to or smaller than 90 degrees with the renal pelvis (fig. 3, B) will remain in a gravity-dependent situation (poor drainage) even when the patient rests in an opposite lateral position. Brownlee et al studied patients with stone debris in the lower calices after ESWL.<sup>6</sup> Their findings suggested that multiple sessions of inversion therapy (patients in a head-down position at 60 to 75 degrees) associated with hydration and dorsal percussion could have a beneficial role in the management of such patients. Although they had not considered the lower infundibular angle, we believe that the subject is important. Based on our anatomical findings we inferred that in patients with an angle of greater than 90 degrees formed between the lower infundibulum and the renal pelvis (fig. 3, A) a postural

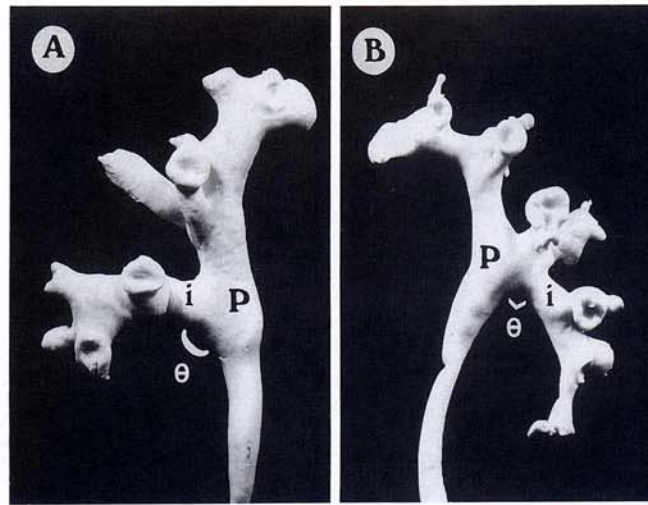


FIG. 3. A, anterior view of pelvicaliceal endocast from right kidney reveals angle ( $\theta$ ) of greater than 90 degrees (115 degrees) formed between lower infundibulum (*i*) and renal pelvis (*P*). B, anterior view of pelvicaliceal endocast from left kidney reveals angle ( $\theta$ ) smaller than 90 degrees (50 degrees) formed between lower infundibulum (*i*) and renal pelvis (*P*).

drainage with the patient in an opposite lateral position might have the same beneficial role as a 60 to 75-degree head downward position.

Taking into account these anatomical details, in patients with stones in the lower calices a radiological study before ESWL should be done on anteroposterior, lateral and oblique films to determine accurately the inferior pole collecting system anatomy. In some cases even the use of computerized tomography (CT)<sup>17</sup> or magnetic resonance imaging may be helpful to ascertain the precise spatial caliceal anatomy. Recently, a method that allows for a more detailed preoperative assessment of pelvicaliceal anatomy by reprocessing of standard CT to produce 3-dimensional images has been described.<sup>18</sup>

Based on careful imaging studies the physician may detect the cases in which, associated with the gravity-dependent position of the lower calices, there are other anatomical features (multiple calices, infundibula smaller than 4 mm. in diameter and infundibular angle close to or smaller than 90 degrees) that may inhibit the evacuation of stone fragments. The physician can advise the patients with these restrictive anatomical features that they have a greater risk for fragment retention after ESWL. In these cases percutaneous procedures alone or complementary with ESWL may be proposed to treat stones in such lower calices. Clinical trials performed at stone treatment centers will be convenient to investigate the correlation between our findings concerning the inferior pole collecting system anatomy and the lower caliceal stone-free rate after ESWL.

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