Brazilian Journal of Urology
Official Journal of the Brazilian Society of Urology
Vol. 27 (1): 3-9, January - February, 2001

LOWER POLE RENAL CALCULI: WHEN AND HOW TO TREAT

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ABSTRACT

This article addresses the respective roles of shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PCNL), ureteroscopy (URS), open surgery and laparoscopy as they pertain to the management of lower pole calculi, an area of ongoing controversy.

Lower pole stones that are symptomatic, locally obstructing, infection related, or increasing in size require intervention. Smaller, asymptomatic stones can be managed expectantly, though with periodic follow-up a significant number will exhibit increasing size or become symptomatic. For most stones smaller than 1 cm, SWL is the treatment of choice while for stones greater than 2 cm, percutaneous management is generally indicated. Stones in the range of 1 - 2 cm represent an area of ongoing controversy regarding respective roles of SWL, PCNL and ureteroscopy. In such cases, consideration should also be given to intrarenal anatomy and stone fragility in determining appropriate therapeutic intervention.

Key words: kidney calculi; lithotripsy; percutaneous; ureteroscopy; lower pole
Braz J Urol, 27: 3-9, 2001

INCIDENCE

While the true incidence of lower pole calculi is difficult to estimate, two recent studies have examined the incidence at the time of SWL. In 1994, Lingeman and associates reported the incidence of lower pole calculi treated by SWL as determined by a meta-analysis of available publications (1). Their study suggested a significant increase in the frequency of lower pole calculi treated by SWL from 1984 to 1991. In 1984, only 2% of stones treated by SWL were located in a lower pole calyx. However, by 1991, such stones accounted for 48% of those treated. Subsequently, Cass et al revisited the incidence of lower pole stones at the time of SWL, and prospectively evaluated the frequency of lower pole calculi treated at two large multi-user lithotripsy sites (2). They noted that the proportion of lower pole calculi treated at those centers was relatively constant during the period studied. In 1989, 28-35% of stones treated were lower pole stones, while in 1995, the incidence was essentially unchanged at 30-36%.

From these two studies, it can be inferred that the number of lower pole stones treated by SWL increased between 1984 and 1991, but has remained essentially constant since that time. This apparent increase in frequency in lower pole calculi can likely be accounted for by the increased availability of lithotriptors during those periods of study. When lithotriptors first became available in the mid 1980's, the "backlog" of pelvic calculi were treated first. As the availability of lithotriptors increased and the indications for treatment expanded, so did the number of lower pole calculi treated. In any case, the fact that one third of renal calculi currently treated by SWL are located in the lower pole underscores the clinical importance of this topic.

INDICATIONS FOR TREATMENT

The indications for treatment of lower pole calculi are the same as those for stones located in other pyelocalyceal locations. These indications include increasing stone size, localized obstruction, associated infection, and acute or chronic pain (3-5). A contemporary area of controversy is whether small, non-obstructing, asymptomatic calyceal stones should be treated prophylactically. In 1990, Hubner reported the natural history of asymptomatic calyceal stones and showed that such stones frequently increase in size or become infected or otherwise symptomatic (6). In 1992, Glowacki et al. reported a prospective study in which they followed patients with asymptomatic renal stones for up to 5 years (7). They noted that the risk of a symptomatic episode or need for intervention was approximately 10% per year, with a cumulative 5 year event probability of 48.5%. In 1996, Mahoney et al. stratified this risk according to stone size (8). They showed that for asymptomatic stones larger than 1 cm, the risk of developing a symptomatic episode within 2 years was 47%.

From this data it can be concluded that even asymptomatic calyceal stones carry a significant risk of becoming symptomatic, and some form of prophylactic intervention may be offered, especially for stones > 1 cm in size. For smaller, asymptomatic stones, there still exists no consensus as to whether prophylactic treatment should be offered.

TREATMENT OPTIONS

Shock Wave Lithotripsy

SWL was first introduced in 1980 and is currently the treatment of choice for most patients with renal calculi (9). However, several investigators have recently questioned the efficacy of SWL for lower calyceal stones, with the expressed concern that the dependent position may inhibit fragment passage. In fact, the reported results of SWL for lower calyceal stones have varied widely. In Lingeman's meta-analysis, it was noted that reported stone-free rates ranged from 25 - 84.6%, with an overall stone free rate of 59.2% (1). When outcome was stratified by stone burden, they found that of those patients treated for stones smaller than 1 cm, the stone free rate after a single SWL treatment was 74%. However, for stones measuring 1 - 2 cm, the stone free rate was 56%, and for stones larger than 2 cm the likelihood of a stone free result was only 33%. Based on this, the authors questioned whether a percutaneous approach should be considered a primary treatment instead, particularly for stones greater than 1 cm in size. In contrast, other investigators have shown equivalent and even superior stone free rates for lower pole calculi compared to those in other pyelocalyceal locations. Drach et al. demonstrated a post SWL stone free rate of 71% for lower pole calculi, compared to 76% and 64% for mid and upper pole calculi respectively (10). For stones smaller than 1 cm, Clayman and associates found that the post SWL stone free rate was 75% for lower pole stones, compared to only 65% and 68% for stones located in mid or upper calyces (11).

Clinical Significance of Post-SWL Residual Fragments

The clinical significance of small (< 4 mm) residual fragments after SWL is a particular source of controversy. In an effort to define the natural history and clinical significance of such fragments, we followed 160 patients with residual fragments < 4 mm after SWL (12). By one year, 23.8% of patients became stone free and this probability increased to 36% at 5 years. However, fragments were found to increase in size in 18.1% of patients during that time. We subsequently reported our experience with 206 patients treated with SWL for isolated lower pole calculi, primarily in respect to the fate of those patients with residual fragments (13). The overall stone-free rate of 54.3% was comparable to that reported by others (1). Of those with residual fragments, 12.6% demonstrated stone growth, became symptomatic or required a secondary intervention after a mean follow-up of 33 months. We concluded that while most residual fragments after SWL can be managed expectantly, they clearly carry the potential of becoming clinically significant, and periodic follow-up is a indicated.

Because residual fragments may have important clinical implications, several authors have described the use of adjunctive measures designed to improve their clearance. In 1992, Nicely et al. described the use of intra-SWL retrograde irrigation through a cobra catheter (14). In patients in whom this adjunctive measure was applied, 71% were stone free at 3 months compared to 54% in the control group. Subsequently, Graham & Nelson described percutaneous irrigation as a means to decrease residual fragments (15). This would seem to compromise the non-invasive benefits of SWL, however, and one could argue that if a patient is to be subjected to percutaneous nephrostomy tube placement, perhaps the tract should be dilated and the stone removed directly.

Others have attempted to improve stone free rates after SWL for lower pole calculi by controlling patient position after treatment. Brownlee and colleagues reported their experience with multiple sessions of controlled inversion therapy after SWL and suggested that it might have a beneficial role in the clearance of fragments after SWL (16). After evaluating the efficacy of inversion therapy, hydration and flank percussion however, Netto found that while such treatment is safe and well tolerated, these measures did not improve the passage of fragments (17). More recently, Honey et al. combined mechanical percussion with inversion therapy and documented radiographic evidence of fragment movement, thus suggesting that it may improve clearance (18). More studies in this area may prove valuable.

The role of early repeat SWL is another source of controversy. Some investigators have advocated the use of repeat SWL for persistent fragments. Parr et al. treated 22 patients with residual fragments with repeat SWL and found that in those patients with anatomically normal calyces, 67% became stone free or had a significant decrease in residual fragments (19). Krings et al. prospectively evaluated the utility of repeat (“stir-up”) SWL in 67 patients with small residual fragments after SWL (20). In the retreatment group 42% were rendered stone free and another 42% had decreased stone burden. Of those in the control group only 4% became stone free and 17% had decreased stone burden. Moon and associates offered repeat SWL to those with residual fragments at 6 months, and 75% subsequently became stone free (21). With time however, many of these fragments will pass spontaneously or remain asymptomatic, and whether the cost and patient inconvenience of repeat treatment is justified remains an area of question.

Appropriate medical adjunctive treatment in the setting of residual fragments is another alternative that has been shown by several authors to both inhibit regrowth of residual fragments and reduce recurrence rates. Cicerello et al. randomized those with small residual fragments to receive either oral citrate or “conservative” management (22). Growth of residual fragments was demonstrated in 46% of the control group but only 20% of those receiving citrate. At 12 months, the stone free rate among those receiving medical therapy was 86%, while in the control group it was only 40%. In 1995, Fine and associates examined the effect of selective medical therapy on those with residual fragments after SWL (23). Of those who received medical therapy, only 16% experienced fragment growth compared to 54.5% of those in the control group. In this setting, appropriately directed medical therapy clearly has a role in minimizing fragment regrowth rates.

Patient Selection for Shock Wave Lithotripsy

Intrarenal Anatomy

Given the variable results reported with SWL for lower pole calculi, some investigators have attempted to examine variables that may predict SWL outcome, and therefore improve patient selection. Sampaio & Aragão created three-dimensional polyester resin endocasts of collecting systems from cadaver kidneys, and suggested that anatomic features of the lower pole calyx may play a role in post SWL stone clearance (24,25). Factors felt to adversely affect stone clearance included an acute infundibular angle, long infundibular length, and narrow infundibular width.

In a subsequent prospective study, Sampaio and associates found that when the infundibulo-pelvic angle was > 90°, 75% of patients became stone-free, compared to only 23% of those with acute angles less than < 90° (26). Sabnis and colleagues, in a retrospective study, showed that for patients with infundibulo-pelvic angles greater than 90° and infundibular width > 4 mm, stone free rates exceeded 80% (27). In contrast, for patients without these favorable characteristics, stone free rates were only 22 - 36%. Elbahnasy evaluated 120 patients treated with SWL for lower pole stones ≤ 1.7 cm and found that an infundibulo-pelvic angle > 70°, infundibular length

< 3 cm, and infundibular width > 5 mm predicated a high stone-free outcome (28). For patients with all three favorable factors the stone-free rate was 91%, compared to only 44% for those with unfavorable factors. While similar findings have been found in other recent studies as well (29), some have questioned the validity and clinical usefulness of such measurements. Recently, Pace and associates examined 50 outpatient intravenous pyelograms and found that there was a wide variability in lower calyceal infundibular width measurement between films, thus questioning the usefulness of this measurement (30). In fact, in a prospective analysis of lower pole calculi from the Lower Pole Study Group examining lower pole infundibulo-pelvic angle as well as infundibular length and width, no difference was found in these variables among those who did or did not become stone free (31).

Stone Fragility

Stone composition is a known predictor of stone fragmentation with SWL. In general, uric acid, calcium oxalate dihydrate and struvite fragment readily with SWL while cystine, calcium oxalate monohydrate and some calcium phosphate stones may fragment less readily. Unfortunately, the stone composition in many patients is not always known prior to treatment.

The term stone fragility was first coined by Dretler, and implies the susceptibility of a particular stone to fragmentation by SWL (32,33). In this regard, an assessment of stone fragility by non-invasive imaging modalities would be useful. Dretler suggested that the plain X-ray appearance could help differentiate the subtypes of calcium stones and predict fragility (32). For example, Wang et al. noted that smooth, homogenous appearing stones required significantly more shock waves to fragment than did stones with an irregular margin (34).

More recently, computerized tomography (CT) attenuation values in Hounsfield units have also been used to predict fragility. Wang and associates found that those stones with unfavorable X-ray characteristics had higher CT attenuation values and were more difficult to fragment (34). Similarly, Mostafavi and associates showed that helical CT attenuation values could accurately predict stone composition *in vitro* (35). In a recent study, Saw et al. measured the number of shock waves need to fragment calcium stones *in vitro* (36). They found that the shock wave requirements correlated with the helical CT attenuation values when the scans were performed at 3-mm cuts. The number of shock waves required to fragment a stone was generally less than one-half the CT attenuation values in Hounsfield units. Using this “half-attenuation rule”, they were able to predict fragmentation in 95% of stones. This is a promising area of clinical research.

Percutaneous Nephrolithotomy

With the minimal morbidity and widespread availability of SWL, PCNL had assumed a diminished role in stone management over the past two decades. Several indications remain well accepted, however, including stones failing SWL, stones associated with distal obstruction, and the occasional patient in whom SWL is contraindicated for factors such as body habitus or proximate calcified aneurysm. Additionally virtually all studies to date comparing SWL and PCNL demonstrate an inverse relationship between stone burden and stone free rates after SWL, particularly in the lower pole calyx. In contrast, the success of PCNL is almost independent of stone size (1,31). Stone burden, therefore, is a well recognized factor in the decision for SWL or PCNL.

In Lingeman’s 1994 study, lower pole stones were stratified by size to less than 1 cm, 1 - 2 cm, and > 2 cm in size (1). The stone free rates after one SWL treatment among these three groups was 74%, 56% and 33% respectively. In contrast, the stone free outcome after PCNL for these same groups was 100%, 89% and 94%. Cass et al., in 1996, reviewed studies specifically comparing SWL and PCNL for lower pole calculi in terms of rates of retreatment, complications, and length of hospitalization (2). They concluded that SWL was the treatment of choice for stones less than 2 cm. For those with larger calculi, the risk-benefits analysis was in favor of PCNL. A recent prospective analysis of SWL versus PCNL for lower pole stones revealed that at 3 months follow-up, the stone free rate after SWL for stones 1 - 2 cm was only 23% and for stones 2 - 3 cm only 14% were rendered stone free

(31). For these same categories, the stone free rates after PCNL were 93% and 86% respectively. Based on this, it was suggested that consideration should be given to PCNL for lower pole stones > 1 cm.

In the current economic climate, the cost-effectiveness of each treatment modality is an important consideration. In Carlsson's study in 1992, the cost-effectiveness of SWL vs. PCNL in the treatment of lower pole stones was evaluated. They showed that while both treatments were efficient, SWL was less costly (36). May & Chandhoke addressed the issue of cost when stratified by stone size (37). For stones less than 2 cm, cost analysis favored SWL, but for stones greater than 2 cm, this cost analysis again favored a percutaneous approach.

Ureteroscopic Management

With technical improvements in flexible ureteroscopes and the addition of newer intracorporeal lithotriptors such as the Holmium laser, ureteroscopy has become a viable option for management of lower pole calculi. In 1998, Fabrizio et al. examined the results of ureteroscopic management in those patients in whom SWL or PCNL was contraindicated or had failed previously (38). The stone free rate after treatment was 77%. Grasso & Ficazzola subsequently reported their results with a ureteroscopic approach, specifically for patients with lower pole calculi (39). For stones less than 2 cm, the stone free rate was 94%, with operative times less than one hour. For stones greater than 2 cm however, the stone free rate dropped to 45% and operative time increased to over 2 hours. Kumar et al. suggested assessment of the infundibulo-pelvic angle in patients in whom this approach is being considered (40). In their study, acute angles (less than 25 degrees) often precluded ureteroscopic access. Ultimately, the role of flexible ureteroscopy in the armamentarium of management options for lower pole stones remains to be determined, but its use seems to be increasing. Currently, such an approach does seem ideally suited to smaller stones, especially in patients in whom SWL has failed or is contraindicated.

Open / Laparoscopic Intervention

With continued advances in minimally invasive therapy, the role for open stone surgery continues to diminish. A 1989 review noted that open surgery was required in only 4% of cases (41) and this figure is even lower today. For lower pole stones, the role of open or laparoscopic intervention is essentially limited to partial nephrectomy for patients in whom a stone is associated with a localized area of irrevocably poor function (42,43).

CONCLUSIONS

Lower pole stones that are symptomatic, locally obstructing, infection related, or increasing in size require intervention. Smaller, asymptomatic stones can be managed expectantly, though with periodic follow-up a significant number will exhibit increasing size or become symptomatic. For most stones smaller than 1 cm, SWL is the treatment of while for stones greater than 2 cm, percutaneous management is generally indicated. Stones in the range of 1 - 2 cm represent an area of ongoing controversy regarding respective roles of SWL, PCNL and ureteroscopy. In such cases, consideration should also be given to intrarenal anatomy and stone fragility in determining appropriate therapeutic intervention.

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Received: November 13, 2000
Accepted: December 13, 2000

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