The Open Access Journal of Science and Technology
Vol. 2 (2014), Article ID 101049, 6 pages
doi:10.11131/2014/101049

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Review Article

Impact of Residual Stones following Endourological Treatment of Renal Stones

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Received 30 November 2013; Accepted 20 December 2013

Academic Editor: Luigi Mearini

Abstract. Renal stone disease is one of the common diseases worldwide. Treatment of renal stones is widely variable. It changed markedly during the last three decades from the more invasive open surgery to the less invasive procedures such as shock wave lithotripsy, percutaneous nephrolithotripsy and recently retrograde intrarenal surgery. Though less invasive, these techniques are more commonly associated with residual fragments after therapy. Larger fragments are considered treatment failure and need re-treatment. Conversely, smaller fragments are usually clinically insignificant and might be considered acceptable outcome. Still, these insignificant fragments might become clinically significant or cause complications. In this article, we reviewed the available literature in a trial to report features of these residual fragments, their clinical significance, their incidence after the commonly performed minimally invasive renal stone therapy, the different imaging modalities used to detect these fragments, the fate of these fragment and the possible lines of management if these fragments are detected.

Keywords: PNL, residual stones after endourology, RIRS, and SWL.

1. Introduction

The management of renal stones is widely variable. It ranges from the non invasive medical treatment to minimally invasive modalities including the shock wave lithotripsy (SWL), retrograde intrarenal surgery (RIRS), percutaneous nephrolithotripsy (PNL) and laparoscopic stone removal reaching to the most invasive; open surgery. The choice of the modality of treatment depends on several factors but the most worldwide recommended procedures are the endourologic procedures [1].

Traditionally, residual fragments after open surgery might be considered as treatment failure. However, the presence of stone fragments after minimally invasive surgery is common as the stone clearance is not immediate [2]. Since long time, these residual fragments represent a controversial problem [3].

2. Definitions

Residual fragments refer to all fragments remaining in the urinary tract 3 months after the last intervention. The term "clinically insignificant residual fragments" or "CIRF" was firstly referring to residual fragments after SWL that are smaller than 4 mm (or sometime 5 mm), asymptomatic, non-obstructive, non-infectious, and associated with sterile urine. This term was extended to include stones with similar characters left behind after PNL or URS. Residual fragments larger than 5 mm are generally considered treatment failure and require another intervention [4–6].

Despite the widespread use of the term CIRF, it remains a controversial problem. Some investigators consider this term as a "misnomer" as the significance and fate of CIRF after SWL remains unclear [2]. Others consider that the application of the term CIRF may not be appropriate as a significant number of patients with CIRF if followed expectantly would require intervention or have symptomatic episodes or complications [4, 7]. Others consider the term CIRF should not be employed to describe residual fragments after SWL and suppose that residual fragments should not be considered as success of SWL and cannot be incorporated in the percent of stone-free patients. They believe that efforts should be performed to obtain true stone-free status [8]. In a recent study, Raman et al found that second intervention may be of benefit in patients with residual fragments larger than 2 mm. Hence, there is controversy about the accurate size of the (CIRF) that can be left behind after any procedure or whether there must be complete clearance and any residual stones are significant [9].

3. Incidence

Not only the incidence of residual stones after SWL and PNL but also the incidence of CIRF that becomes clinically important is widely variable between different studies. This might be partly related to the time of evaluation as parts of these residual gravels may pass gradually changing the stone free percent of patients with time [6, 10].

Some studies found that, in SWL, 78.6% of patients were discharged with residual stones. 56.1% of them were cleared of their fragments spontaneously within 4 weeks and 22.5% of them did so within 6 months. It was noted that more than 98% of spontaneously cleared stones did so within the first 12 weeks after SWL [8, 11]. Shigeta et al. examined patients with CIRF 3 months after SWL and could show that only 14.3% of patients reached a stone free state during a further 20-month followup [12].

Most studies showed stone free rate after PNL ranges from 40% to 90% depending on the size, number, composition, nature of the stone, and surgeon's experience. This means that the incidence of residual stones after PNL ranges from 10% to 60%. But some of these studies with high success rate accepted the CIRF as being stone-free [13].

4. Diagnosis

The capability to detect residual fragments is dependent on the imaging modality. Traditionally, postoperative plain X-ray of the urinary tract (PUT) and abdominal ultrasound (US) were the main tools of diagnosing residual stones, and there are many centres still depending on them for evaluating the stone-free rate mostly because of the availability and the probable lower cost and less radiation exposure than CT [14–16]. However, plain X-ray including intravenous pyelography (IVP), have some disadvantages namely its sensitivity and specificity that can be as low as 62% and 58%, respectively. These low percents are due to factors like intestinal gas, bone shadows and geometric magnification leading to stone size distortion [17].

The specificity of US in the literature has been declared as 61% [17]. The greatest weakness of US is its inability to show the entire ureteral course. Large patient habitus and bowel gas can contribute to this poor ureteral evaluation. Also, the experience of the radiologist plays an important role in the accuracy of US. For these reasons, US is not generally recommended to express the success of SWL except in radiolucent stones. Some authors advocate the use of transvaginal or transperineal US to improve stone detection. Nonetheless, these methods are not worldwide accepted [18, 19]. In a trial to improve the accuracy of US, color flow analysis of the ureteral jets was performed. Unilateral abnormal ureteral jet can point to obstruction. Still, US cannot show the location of the obstructing lesion. Another pitfall is the fact that normal ureteral jets cannot exclude ureteral obstruction [20].

Helical CT can detect urinary tract calculi with very high accuracy. It seems to be the method of choice for the detection of residual fragments. Improved soft tissue to stone contrast, the elimination of respiratory artifact by rapid image acquisition and the availability of image reconstruction have made helical CT highly sensitive. Even for radioopaque stones, helical CT detected residual fragments in patients who were thought to be stone-free by PUT. Uric acid and cystine stones that might easily be missed by PUT due to their relatively poor radioopacity can easily be detected using CT. The average stone size detected by helical CT is as low as 0.01–1.44 cm^2. Helical CT also confirmed every residual stone detected by US. It has 95–100% sensitivity and 96–100% specificity for diagnosing ureteral calculi. The high sensitivity, specificity, negative and positive predictive values of helical CT make it more appropriate in the diagnosis of stone-free patients. It may change the clinical approach in some patients who were thought to be stone-free previously [21–23].

Helical CT has improved detection rate of renal pathologic features than other modalities. This may bring some advantage regarding the detection of complications after SWL such as perirenal hematoma and also renal space-occupying lesions that could not be detected with plain PUT and IVP [24]. Also, CT might be the imaging modality of choice in selected patients as patients having solitary kidneys, ureteral stones, radiolucent stones, and highly recurrent calculi [23].

Compared to IVP, the advantages of helical CT are the nonexistence of the need for intravenous contrast material and the high sensitivity for calculus detection. On the other hand, the main disadvantage of helical CT is the high radiation dose compared with the other techniques [23].

Concerning the cost to examine patients after SWL, some studies found that spiral CT is less costly when compared to combine US and PUT [25]. Others found that although helical CT is definitely not more expensive than IVP however it is more expensive than combined US and plain PUT [23].

Pires and his associates compared the sensitivity of residual stones detection after PNL between PUT and CT and found that sensitivity was 87% and 100%, respectively, especially in the diagnosis of small residual fragments $<$ 5 mm concluding that spiral CT is justified to confirm the absence of residual fragments in patients after PNL despite the higher cost and irradiation compared to PUT [26].

In a prospective study, Park et al., found that 52.4% of their patients who were considered stone-free by PUT had residual stones when they had CT 1 month after PNL [13].

Improved intraoperative imaging has the potential to localize and remove residual stones at initial PNL. Portis and his group used high magnification rotational fluoroscopy with flexible nephroscopy to increase the intraoperative detection of residual stones. Despite these measures, only 60% of patients were stone-free on postoperative−day one−CT. However 40% of patients that were endoscopically and fluoroscopically stone-free had residual stones 4 mm or smaller [27]. Although routine imaging followup seems to be mandatory, to our knowledge there are no current scheduled programs.

5. Fate of the residual stones

Most of the CIRF after SWL pass spontaneously shortly after treatment without any complications [11]. Passage of the gravels often takes several weeks [8]. Although it was noticed that most of the spontaneously cleared stones did so within the first 3 months after SWL, still clearance may persist up to 6 months after the last session [12]. Most of CIRF that were cleared spontaneously did not recur within 5 years [11].

On the other hand, stone fragments retained in the renal collecting system may act as nidi for stone re-growth. They usually grow within 5 years and get clinical significance again. They might also become symptomatic causing pain when obstruction occurs or present a source of infection hence, close followup is mandatory [2, 11, 28].

The possibility of CIRF becoming clinically significant increased as their size and number increased [4, 28]. On the other hand, other investigators failed to demonstrate any significant difference in outcome depending on the size of the CIRF [8, 29].

The presence of residual stones after SWL is not only related to the efficacy of fragmentation where residual fragments are still present in 24% to 36% of cases 3 months after SWL despite efficient fragmentation with resultant fragments less than 5 mm in 85% to 96% of cases [5, 29]. In addition, the site of residual fragments plays a role in stone clearance where the lowest clearance is expected in lower calyceal stone [11].

While Altunrende and associates failed to prove any impact of metabolic factors on stone progression [30], Khaitan and his co-workers found that metabolic abnormality will not affect stone progression if the patient receives the appropriate treatment [28].

Long-term—12 months—followup of patients with CIRF after SWL at 3 months showed that patients who became stone-free are comparable to those who still had dust or residual fragments. Hence, patients with CIRF do not necessitate systematic re-treatment in the short-term but they may be followed up and re-treated if symptoms persist or stones recur [31].

Residual stones after PNL are thoroughly studied as although they may pass spontaneously or remain silent with no growth, they may become symptomatic causing pain, hematuria, recurrent infection and obstruction or act as nidi for stone re-growth [32].

Although PNL has a quite good success rate but residual stones are generally left behind. The presence of residual stones after PNL may be due to presence of many factors as migration of fragments into an inaccessible calyx, termination of procedure due to complications or length of surgery, the complexity of the collecting system or inability to visualize the stone using fluoroscopy [30].

In a trial to find out factors associated with decreased spontaneous passage of residual stones or stone regrowth after PNL, Ganpule and Desai found that 65.5% of patients having residual stones after PNL became free after 3 months. At multivariate analysis they found that previous intervention in the form of SWL, PNL and open surgery have significantly lower clearance rate of residual stones. The problem in those patients is that stone removal from a scarred collecting system might be difficult also the distorted pelvi-calyceal system anatomy may limit the spontaneous passage. Other significant factors found are the metabolic hyperactivity, location (worse outcome in lower calyceal fragments because of the dependent anatomy that hinders spontaneous passage) and size of residual fragments determining that the $>100\,mm^2$ stones require intervention [33]. Patients with infection stones are at particularly high risk for recurrent stones and infection when they have residual stones after treatment [29]. If residual struvite stones are the only significant risk factor, a regrowth rate of 21% was detected [30].

In general, stone recurrence in PNL treated patients is lower than that occurred after SWL. This was confirmed by Carr et al who compared stone recurrence rates at 1 and 2 years after intervention in patients rendered stone free after SWL and PNL. Their results revealed a higher rate of new stone formation in the SWL group (22.2% at 1 year, 34.8% at 2 years) versus the PNL group (4.2% at 1 year, 22.6% at 2 years), suggesting that residual "dust" after SWL that may not be identifiable on standard radiographs places patients at higher risk for stone recurrence [34].

6. Management

During SWL, It was noticed that treating patients at slower shock wave rate, using a step-wise ”power ramping” protocol, at as low a power level as possible and the use of broad focal zone machines could improve stone breaking and hence the SWL outcome [35].

During PNL, the use of single pulse mode lithotripters results in controlled fragmentation and formation of larger sized fragments. These fragments will be easily picked up and will have fewer chances to scatter [36]. The use of ultrasonic lithotripters with continuous suction simultaneously evacuates the stones fragments leading to fewer residues [30]. Specially designed Amplatz sheath that reduces intrarenal pressure and facilitates stone removal by irrigation fluid without increasing the intrarenal pressure was also described [37]. Another method to decrease residual fragments is the routine use of flexible nephroscopy combined with that of high resolution fluoroscopy [26]. In case of doubtful residual stones it is advisable to place a PCN tube to facilitate a later 2nd look procedure [1].

Diuresis, vibration massage, mechanical percussion and inversion therapy were demonstrated to improve the outcome of patients with residual lower calyceal stones [38, 39]. Recently, a method to improve stone clearance has been described in which stone fragments in the renal pelvis can be moved using transcutaneous focused ultrasound [40]. Other investigators tried early retreatment after SWL and achieved further success in 40% to 83% of cases [41, 42]. However, systematic SWL retreatment of all asymptomatic patients was not justified by others [2, 10, 31, 42].

Several studies found that medical therapy has been shown to be effective in preventing stone growth and recurrence. Discontinuation of medical therapy in patients with CIRF was associated with stone growth during followup suggesting that these fragments were not insignificant [28, 43–45]. However, others believe that this topic needs additional investigation [11].

Some investigators assume that the size of residual stones is the main factor in choosing the suitable line of their treatment supposing that stones $>$ 6 mm and symptomatic stones $<$ 4–5 mm are indications for active stone removal. On the other hand, they believe that asymptomatic stones $<$ 4–5 mm are a reasonable indication for followup [1]. These recommendations were−−to some extent−−doubted by the findings of Raman and his group who observed that more than half of their PNL patients with residual fragments larger than 2 mm required a second surgical procedure [9]. For those patients that are indicated for active removal of residual stones the selection of the modality of treatment is the same as for the primary stones [1].

The patients with residual fragments should be informed in details about the risk of any possible complications of initially (CIRF) and the eventual need for auxiliary treatment [30].

7. Conclusions

Residual fragments represent a controversial problem. CIRF is still a hazy term that needs to be more clarified. Spiral CT is the most accurate radiologic tool in detection of residual fragments. Despite the fact that close followup of patients with residual fragments seems to be mandatory, there are no current scheduled programs for such followup.

Acknowledgment

The authors want to acknowledge Dr. Hosny M. Bahnasawi for his meticulous support in references’ collection.

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