The Endourological Treatment of Renal Matrix Stones

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Key Words

Matrix stones · Percutaneous lithotripsy · Retrograde intrarenal surgery · Laser lithotripsy

Abstract

Objective: To report our experience with the endourological treatment of renal matrix stones, an infrequent form of urinary calculi whose diagnosis and treatment are often difficult. **Methods:** From 1990 to 2010 we treated 9 female patients with matrix calculi using the endourological approach; 4 presented with renal colics, 3 with symptomatic urinary tract infection and 2 with asymptomatic bacteriuria. Six patients underwent percutaneous lithotripsy and 3 retrograde intrarenal surgery as first-line therapy. Three cases needed a multidisciplinary approach. **Results:** The six percutaneous procedures were successful after a single session, while the retrograde approach required multiple treatments; a single case needed a shock wave session to complete the fragmentation, in another one a percutaneous lithotripsy was necessary after the first procedure, and a third case needed multidisciplinary treatment. **Conclusions:** Percutaneous lithotripsy has been confirmed as the first option for matrix stones. The retrograde approach – by confirming the suspected di-

agnosis and being minimally invasive – may be employed to treat either lower-size stones or stones at high risk of recurrence.

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Introduction

Renal matrix stones – also known as fibrinomas, colloid calculi or albumin calculi – are a rare form of calculi first described in 1908 by Gage and Beal [1]. In contrast to the normally brittle calcium stones, they are soft, pliable and amorphous, since the matrix component accounts for approximately 65% of their dry weight instead of 2.5%; accordingly, matrix stones appear radiolucent or weakly radiopaque due to their very low content of mineral components [2].

In most cases, conventional radiological techniques are unable to make a correct diagnosis of renal matrix stones. Intravenous urography does not always help distinguish between matrix stones and other filling defects, whereas computed tomography (CT) is more reliable in diagnosing this particular type of calculi. However, an unquestionable diagnosis is usually made at surgery.

Table 1. Demographics

Age, median (range)	50 (4–69)
Male/female	0/9
Unilateral/bilateral	9/0
Presenting symptoms	
Flank pain	4
UTI	3
Asymptomatic	2

Table 2. Summary of patients treated for matrix calculi

Patient No.	Age, years	UTI	Stone location	Treatment
1	4	–	pelvis	PCNL
2	65	+	pelvis	PCNL
3	49	bacteriuria	pelvis, lower calyx	PCNL
4	27	bacteriuria	staghorn	PCNL
5	35	–	staghorn	PCNL
6	69	–	pelvis	RIRS + SWL
7	56	–	upper calyx	RIRS + PCNL
8	52	+	staghorn	PCNL
9	50	+	multiple	see text

To the best of our knowledge, up to now 60 cases have been reported. All patients were treated with surgical approach or, since 1990, with percutaneous nephrolithotripsy (PCNL) [3–5]. Herein, we report our experience with the endourological treatment of this relatively rare entity.

Patients and Methods

We treated 9 female patients (median age 50 years) (table 1). Four patients complained of flank pain; the diagnosis was made after radiological investigations for urinary tract infection (UTI) in 3 other patients and for asymptomatic bacteriuria in the remaining 2 cases.

The localizations and characteristics of stones are reported in table 2. In 3 patients they were localized in the renal pelvis and in 1 in the upper calyx; in 1 case the calculi were in the pelvis and the lower calyx, and in 3 cases they occupied the whole collecting system (staghorn stone). Only in 1 case did we find multiple stones in different calyces. At primary evaluation the stone burden was always >25 mm.

The treatment was not uniform and in 3 cases we performed a multidisciplinary approach.

We used percutaneous lithotripsy with a single access through a lower calyx. After dilation with a balloon catheter and positioning of a 30-F Amplatz sheath, the matrix stones were aspirated or

Fig. 1. RIRS. Multiple matrix calculi (a): the calcareous component was treated by holmium:YAG laser lithotripsy (b). The fragments and the matrix component were removed using a basket (c).

removed with forceps. When a hard component was present, we used ultrasound lithotripsy and forceps to take out residual fragments. A flexible nephroscope was useful to examine all major and minor calyces in order to obtain complete clearance with a single procedure.

In the retrograde approach with ureteroscopy (retrograde intrarenal surgery, RIRS), either 8-F semirigid or 7.5-F flexible instruments were employed. After positioning a safety guidewire, semirigid ureteroscopy was carried out to examine the ureter and to reach the intrarenal cavities; subsequently, the matrix component was evacuated with either forceps or basket, or with an aspirator directly connected to the instrument. Holmium:YAG laser was used to fragment the calcareous component or to cut the matrix material in order to reduce its volume and to facilitate its removal (fig. 1). The flexible ureteroscopy was employed for inaccessible calyces (middle and lower calyces) after placing an 11/13-F ureteral sheath in most cases. Shock wave lithotripsy (SWL) was used to treat any residual fragment of hard component.

Fig. 2. CT scan with three-dimensional reconstruction: filling defects in upper and lower calyces.

Results

The first-line treatment in 6 patients was PCNL with complete clearance in a single session. One patient (No. 6) was treated with RIRS and SWL of residual fragments; an additional patient (No. 7) was treated with RIRS and after that with PCNL since the retrograde approach had not been able to achieve complete removal of this large stone. In this patient, the retrograde approach was also indicated to establish the diagnosis of a suspicious filling defect in the collecting system.

A 50-year-old patient (No. 9) deserves a detailed comment. Having multiple calculi of the calyces, she underwent retrograde lithotripsy at two different times, with only partial removal. Therefore, she underwent a PCNL procedure and a subsequent SWL, with complete clearance of all stones. Some time later, after recurrence of her stones, a surgical approach with pyelolithotomy was performed in another center. A few weeks later, this procedure was complicated by urinary infection caused by *Proteus mirabilis*, and the stone disease relapsed very quickly. CT scan showed multiple filling defects in the upper caliceal system and other filling defects in a lower enlarged calyx (fig. 2). We performed PCNL and multiple RIRS because of early stone relapses. The urinary infection was never completely eradicated. Due to the technical difficulties in achieving complete removal, we decided to perform lower pole surgical resection. The patient is still free from calculi and urinary infection 24 months after surgery.

In all patients the stone composition consisted of both matrix and amorphous material; their mineral component was calcium phosphocarbonate in 1 case, calcium oxalate monohydrate in 2 cases, uric acid and ammonium urate in 2 cases and magnesium ammonium phosphate in 2 cases. In the remaining 2 cases the stone composition was a mixture of calcium oxalate and uric acid.

Discussion

Matrix stones are an uncommon form of renal lithiasis. The matrix bulk accounts for approximately 65% of dry weight, with a very low percentage of the mineral components [2]. Boyce and Garvey [6] demonstrated that this organic substance is similar, but not identical, to the matrix component of the calcareous stones. According to their analysis, the matrix consisted of mucopolysaccharide (one third) and protein (two thirds); the main components of carbohydrates were hexose and hexosamine, whereas threonine, leucine, serine, tyrosine, arginine and lysine were the most common amino acids of the protein component.

Despite their fibrillar structure – as shown by electron microscopy analysis of matrix stones formed in similar patients with proteinuria and on hemodialysis – the proteinaceous material differs from Tamm-Horsfall protein [7].

The role of the matrix substance in crystalline calculi is not completely understood. Matrix might provide a

framework for deposition of crystals or be a co-precipitate in a mineralogical environment [8, 9]. The reason for the failure of crystal deposition in matrix stones is also unknown. Histological examination shows laminar concentric rings of organized matrix with an orderly, layered deposition of mineral. Bani-Hani et al. [4] believe that reduced urinary excretion of calcium by the affected kidney is responsible for the lack of calcifications, but it is possible that the normal calcium excretion by the contralateral kidney compensates for the 24-hour urinary calcium amount. Indeed, all our patients were normocalciuric and we did not find any alteration at metabolic screening.

While normal stones are more common in males, matrix calculi are more frequently seen in females [3]. The main risk factors for this type of stones are previous surgery for stone disease [5] and/or recurrent UTIs, especially due to *P. mirabilis* or *Escherichia coli*. In our group of 9 female patients, 3 had been affected by symptomatic recurrent UTI and 2 had asymptomatic bacteriuria, all of them with urine culture positive for *E. coli*. Only 1 patient had previously been repeatedly (11 times) treated for stone disease. In this patient, urine culture was positive for *P. mirabilis*.

The link between kidney matrix stones and chronic kidney failure is of interest, especially in patients on maintenance hemodialysis, in whom proteinuria and/or UTI or positive urine culture could represent risk factors for developing matrix stones [5, 7].

The clinical presentation of patients with matrix stones is similar to those with calcium nephrolithiasis, flank pain and UTI being the most common symptoms. The tendency of these stones to adapt themselves to the shape of the renal pelvis and ureter may lead to gradual obstruction of the urinary tract, sometimes resulting in acute renal failure in patients with bilateral disease [10, 11].

The imaging of matrix stones can be difficult because no specific radiological investigation is available: in most cases, the diagnosis is only made after surgery [5]. The radiological appearance of these stones can be variable. Bani-Hani et al. [4] reported the presence of gas in the renal pelvis, probably secondary to active infection. Intravenous urography in these patients is often of poor diagnostic value due to impaired renal function, which makes the contrast medium inadequate to outline the filling defects. Retrograde pyelographic studies can help see the filling defects, which, however, must be evaluated in the differential diagnosis with tumors, clots, polyps or other types of calculi.

Ultrasound imaging shows a solid structure without the classic hyperechogenicity of stones and acoustic shadowing, depending on the amount of mineralization.

The CT scan appearance of matrix stones varies, depending on mineral volume, composition and internal distribution. Some authors described egg-shaped matrix stones with a mineral rim and soft tissue center [4, 12, 13]. In our series the Hounsfield units (HU) were evaluated just for 1 patient (No. 9), the value being between 500 and 600 HU. This value is not suitable to define the chemical composition of stones and it does not help in the diagnosis of matrix stones. In fact, just for HU >1,000 or <400 it is possible to predict the stone composition (CaOx vs. urate) [4, 12, 13]. For the same reason the CT density does not help in distinguishing matrix stones from other disease.

Magnetic resonance imaging has also been tested for the diagnosis of matrix stones disease because of the low nephrotoxicity of gadolinium. Typically, matrix stones show a hypointense signal in T1-weighted images and a slight hyperintense signal in T2-weighted images [14].

When treatment is planned, two factors should be considered: the probability of fast growth and the possibility of a spontaneous, although exceptional, expulsion. Lower-size calculi usually have a negligible chance of progression along the urinary tract and therefore treatment is mandatory.

In the past, open surgery was the preferred technique [3]. Due to the soft consistency of the stones, methods like milking of the proteinaceous material from the ureter into the bladder or use of a special bottle brush to clear the pelvicalyceal system were used during this procedure [8, 15].

Nowadays, the most appropriate choice in the treatment of matrix stones is the endourological option. Both procedures, the antegrade (PCNL) and the retrograde (RIRS) one, have been used by various authors [3–5, 16–18]. PCNL may be safe and effective to remove matrix calculi in a single session, while the ureteroscopic approach is often inadequate with large bulk of stones. Therefore, RIRS may represent a valid option especially for lower-size and for recurrent calculi: in case of stones >2 cm, multiple sessions should be considered. Otherwise, the retrograde approach provides a correct diagnosis in doubtful cases.

SWL is usually ineffective due to the stones' gelatinous component and a lack of breakable mineral content [4]. In our series, SWL was only employed for residual mineral fragments.

At variance with some reported evidence of early recurrences in patients with persisting UTI, these stones have a very low recurrence rate, and with the first approach the problem can be definitely solved [5]. Both

washing the pelvis and the calyces after the endourological procedures and eliminating infections can be critical to prevent recurrences. Prophylaxis with antibiotics is believed to be effective to avoid matrix stone recurrences. Unfortunately, however, the length of the treatment period has never been clearly established. Several preparations for lowering urine pH might also be useful in treating patients with infected renal stones [19, 20].

Conclusions

At present, the endourological approach is the first-choice treatment for matrix stones. In most cases, complete stone removal is obtained with PCNL. The retrograde approach is either important to diagnose matrix stones or to treat low-size stones; it should be regarded as the first-choice treatment in patients with high risk of stone relapse. SWL should only be used in patients with stones having a high percentage of minerals. Antibiotic prophylaxis to avoid asymptomatic bacteriuria and UTI

is suggested, although Miwa et al. [20] did not find clinical evidence on the type and the duration of antibiotic prophylaxis. We perform antibiotic prophylaxis based on the international urological guidelines. A close follow-up consisting of urological control with urinalysis and ultrasound every 3 months is suggested in these patients, in order to treat lower-size stone recurrence with minimally invasive surgery. Accurate counselling describing the advantages and disadvantages of all endourological techniques is also mandatory.

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No competing financial interests exist.

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