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Review Article

Staghorn renal stones: a review

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ABSTRACT

Staghorn lithiasis is described as the presence of stones in the urinary tract that create a mold of the renal collecting system, with the characteristic of being branched. It has a strong association with urinary tract infections caused by urea-splitting organisms. The composition of the stone usually consists of pure magnesium ammonium phosphate (struvite), or a mixture of struvite and calcium carbonate apatite. It is classified as complete and partial. In the complete one, the stones occupy the renal pelvis and the calyceal system, or more than 80% of the collecting system; unlike the partial ones that occupy the renal pelvis and at least two calyces. Computed tomography without intravenous contrast is the imaging method of choice for diagnosis and planning of surgical intervention. Allowing an accurate assessment of the morphology and location of the stones; that will set the standard for guiding percutaneous access. Complete stone cleaning is the cornerstone of staghorn lithiasis treatment. The guidelines of the European Association of Urology and the American Association of Urology mention that percutaneous nephrolithotomy continues to be the treatment of choice for large stones. Conservative management is related to renal loss and urosepsis, reporting a mortality of 28 % up to 30% within 10 years, as well as a 36% risk of developing chronic kidney disease.

Keywords: Renal lithiasis, Urology, Staghorn lithiasis, Lithiasis, Percutaneous nephrolithotomy

INTRODUCTION

Definition

Staghorn lithiasis is described as the presence of stones in the urinary tract that create a mold of the renal collecting system, with the characteristic of being branched. The exact definition in terms of size and shape is controversial; Most authors agree in differentiating them by the extension of the calyces involved, since they can occupy all or part of the renal pelvis, extending to several or all of the renal calyces. It is a pathology of great relevance, since it is associated with a high rate of morbidity and mortality.[1-3]

Etiology

Staghorn lithiasis has a strong association with urinary tract infections caused by urea-splitting organisms, the most important of which include *Proteus*, *Klebsiella*, *Pseudomonas*, and *Staphylococcus* species. The most frequent uropathogen; *Escherichia coli*, only 1.4% is capable of producing urease, being a rare cause of staghorn lithiasis.[4] The composition of most staghorn stones consists of pure magnesium ammonium phosphate (struvite), or a mixture of struvite and calcium carbonate apatite. Stones composed of uric acid or cystine may also grow in a staghorn configuration; this rarely occurs with calcium oxalate or phosphate stones.[5] Risk factors associated with staghorn calculi include female gender, congenital malformations of the urinary tract, urinary stasis, urinary diversion, neurogenic bladder, indwelling Foley catheters, distal renal tubular acidosis, and diabetes mellitus.[6]

Epidemiology

In the past it was mentioned that staghorn lithiasis represented between 10% and 20% of stones in the urinary tract. At present, it has been studied that in developed countries it represents 4%, secondary to early and effective therapy.[7] It has a frequency twice as high in the female sex compared to the male. They are generally unilateral, but up to 15% of cases may present both kidneys affected.[8]

Pathophysiology

The pathophysiological process begins when urine is undersaturated with ammonium phosphate, struvite stones are formed when ammonia production increases and urine pH rises, producing a decrease in phosphate solubility. This phenomenon occurs when patients have a urinary infection secondary to a urease-producing organism. Following the following process; urease-producing bacteria produce a breakdown of urea into ammonia and carbon dioxide, to later hydrolyze it into ammonium and bicarbonate ions. Together with the available cations, apatite carbonate and hydrated magnesium ammonium phosphate (struvite) are produced. Carbonate apatite begins to crystallize at a pH greater than or equal to 6.8, unlike struvite which precipitates at a pH greater than or equal to 7.2. Citrate normally binds calcium and magnesium, however this protective effect is lost in infectious processes due to the high concentrations of bacteria which metabolize citrate.

The struvite-apatite powder is formed together with the bacteria, facilitating the growth of the crystals. These crystals grow within the bacteria and, after bacteriolysis, microliths are formed, which favor the growth of staghorn stones.[5] Struvite stones are generated in patients with recurrent urinary tract infections; as well as in pathologies that condition urinary retention, for example, the use of a urinary catheter in a chronic way and voiding neurogenic dysfunction.[9]

Classification

Staghorn lithiasis is divided into complete and partial. In the complete one, the stones occupy the renal pelvis and the calyceal system, or more than 80% of the collecting system; unlike the partial ones that occupy the renal pelvis and at least two calyces (Figure 1).[10]

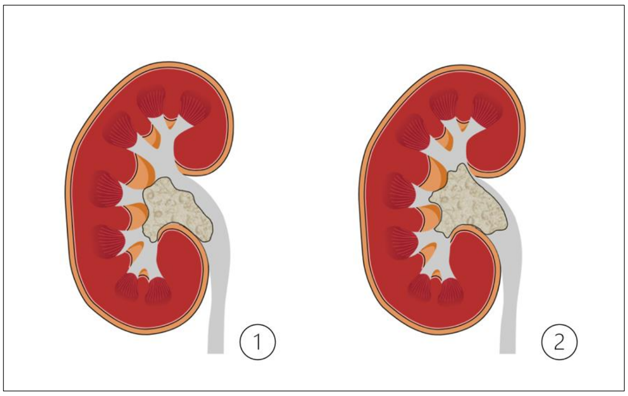

Figure 1: Classification of staghorn lithiasis (1) partial staghorn lithiasis, showing a stone occupying the renal pelvis and two renal calyces, and (2) complete staghorn lithiasis, showing a stone occupying the renal pelvis and calyceal system.

Diagnosis

Patients with staghorn lithiasis usually do not have acute colic; lithiasis is found incidentally, or secondary to subacute abdominal and lumbar pain, recurrent urinary tract infections and/or macroscopic hematuria.[11] A complete medical history should be taken, with emphasis on medical and surgical history, as well as investigating the history of urinary tract infections, episodes of pyelonephritis and/or hematuria.[12]

Laboratory studies

Complete blood count, coagulation times, serum electrolytes, metabolic profile, and serum parathormone levels should be performed. Within the urine studies, a urine culture will be requested, with the aim of starting targeted antibiotic treatment; as well as 24-hour urine collection to comprehensively evaluate the patient. There is controversy between a second 24-hour urine collection, since a second analysis can show disorders not evidenced in the first analysis.[3] Computed tomography without intravenous contrast is the imaging method of choice for diagnosis and planning of surgical intervention. Allowing an accurate assessment of the morphology and location of the stones; that will set the standard for guiding percutaneous access. Stone characteristics on computed tomography, Hounsfield unit measurement, and attenuation can be useful in determining stone brittleness and composition.[13] Some authors have suggested performing a renal nuclear scintigraphy in all patients with staghorn lithiasis, to obtain an adequate evaluation of renal function. The American Association of Urology mentions that if the affected kidney has <10% function, nephrectomy may be the best treatment option.[5]

TREATMENT

Complete stone cleaning is the cornerstone of staghorn lithiasis treatment. The guidelines of the European

Association of Urology (EAU) and the American Urological Association (AUA) mention that percutaneous nephrolithotomy continues to be the treatment of choice for large stones.[14] Conservative management is related to renal loss and urosepsis, reporting a mortality of 28% to 30% within 10 years, as well as a 36% risk of developing chronic kidney disease.[8,15] Due to the relationship of staghorn stones with infection, it is important to perform a urine culture in the pre-surgical approach. If it is positive, specific antibiotic management should be started prior to surgery for 5 to 7 days, even if the patient is asymptomatic. In high-risk patients, specific antibiotics are usually continued for 5 to 7 days after surgery.[15] The AUA recommends starting perioperative antibiotic prophylaxis when PCNL is performed, with a single intravenous or oral dose of an antibiotic that covers gram-positive and negative uropathogens.[16]

Percutaneous nephrolithotomy

Described since 1970, percutaneous nephrolithotomy (PCNL) plays an important role in the treatment of renal lithiasis. It is currently the treatment of choice for staghorn stones. Currently there are several types of endoscopes, among which are flexible and rigid.[16] It has been reported that this endoscopic therapy has achieved a stone-free rate of 98.5% and 71% in partial and total staghorn stones, respectively.[17] Pre-surgical planning is essential. Computed tomography (CT) is the ideal imaging study for the approach in this procedure, since it will guide anatomically to perform an ideal percutaneous tract. The use of ultrasonography and fluoroscopy allow performing a directed renal puncture.[18]

Percutaneous access has changed, and evolved. Available options are single-tract PCNL with an ancillary procedure such as shock wave lithotripsy, single-tract PCNL with flexible nephroscopy, or multi-tract PCNL.[19] The upper pole approach is recommended as it allows a better approach to the pyelocalyceal system and has been associated with a higher stone-free rate compared to the lower pole approach.[20]

Endoscopic combined intrarenal surgery, ECIRS

In 2008, endoscopic combined intrarenal surgery (ECIRS) was introduced, this technique allows the simultaneous use of combined retrograde and antegrade approaches, using rigid and flexible endoscopes.[21] This approach may decrease the need for another percutaneous access as a rigid nephroscope can reach stone fragments in the ureter and renal calyces. Recently, Goktug et al conducted a study where they analyzed the results of conventional percutaneous nephrolithotomy and endoscopic combined intrarenal surgery in the treatment of complete staghorn lithiasis. Comparative analysis revealed that fluoroscopy time, surgical time, length of hospital stays, number of accesses, and hemoglobin drop were significantly less in the ECIRS group compared with the PCNL group.[22]

Ureteroscopy

In the last two decades, retrograde ureteroscopy has been applied to large upper tract stones. This is due to improvements in the flexibility of the ureteroscope, and the miniaturization of the endoscope as well as the accessory equipment. However, comparatively, ureteroscopy is considered inferior to PCNL for the treatment of staghorn stones, due to its lower rate of removal of large kidney stones.[23,24]

The integration of ureteroscopy in a combined antegrade and retrograde approach appears to be advantageous for the treatment of staghorn stones. This is because the antegrade placement of a guidewire and the dilation of the tract are facilitated after retrograde stone reduction. Another advantage lies in the fact that it can be performed with the nephroscope and ureteroscope working synergistically to remove stones. Calyces that cannot be manipulated with the nephroscope may be accessible through the ureteroscope. A "pass the buck" maneuver can be performed where large stone fragments can be moved with the ureteroscope into a position that allows cleaning over the percutaneous tract. Finally, a ureteroscopic inspection of the entire upper urinary tract at the end of the procedure allows evaluation and removal of possible residual stone fragments.[2]

Open surgery

It is reserved for certain circumstances, for example when PCNL is not available, or if the patient has anatomic abnormalities such as pelvic kidney, retrorenal colon, or spinal deformities that make percutaneous access to the kidney difficult.[6] The American Urological Association guidelines recommend anatrophic nephrolithotomy in patients in whom treatment of a struvite staghorn stone is unlikely to be successful with a reasonable number of PCNL. [16]

Urease inhibitors

Urease inhibitors have been mentioned for the treatment of struvite stones, demonstrating a significantly lower recurrence rate, however side effects such as tremors and phlebothrombosis have limited their use.[6] Another limitation lies in the increased risk of toxicity, and decreased efficacy in patients with kidney injury; therefore, it is contraindicated if serum creatinine levels are greater than 2.5 mg/dl. It is also contraindicated in pregnant women and women of childbearing age who are not using contraceptive methods. The guidelines of the American Urological Association establish that such treatment can be considered, when surgical options have been exhausted, in patients with residual or recurrent struvite stones. They also mention its use in patients with alterations in the lower urinary tract, such as neurogenic bladder or urinary diversion, with a diagnosis of struvite and/or calcium carbonate apatite stones, due to the high risk of recurrence.[11]

Urinary acidification and chemolysis

Chemolysis, or dissolution therapy, was described more than 70 years ago. It has a limited role in staghorn calculi due to the long hospital stay, associated costs, and risk of complications.[5]

It is performed by diluting urine and oral (L-methionine, ammonium chloride) or local (citric acid solutions such as Suby G or renacidin) acidification with chemolysis. Suby's solution G consists of citric acid, magnesium oxide and sodium carbonate. Generating chemolysis; as the acids provide hydrogen and citrate ions to form soluble complexes with the calcium (calcium citrate) and phosphate (phosphoric acid) components of the stone. The acidic pH of these solutions is also responsible for their effectiveness, since the solubility of struvite stones increases significantly at a pH less than 5.5. Low intrarenal pressures should be maintained; serum magnesium and phosphate should be monitored, and urine should be sterile. Therefore, broad-spectrum antibiotic management is administered before, during, and approximately 10 days after treatment.[24] Due to advances in endourological techniques, which have proven superior results compared to chemolysis, this treatment is controversial. However, it can be a complement after surgical treatment for the treatment of residual fragments and reduce lithiasis recurrence. Chemolysis with extracorporeal shock wave lithotripsy is described as a feasible alternative in high-risk patients and when other procedures are impossible.[5]

Renal lithiasis culture

Due to the high rate of association of staghorn calculi with infection, it is of vital importance to identify the causative pathogen. For which, stone culture is the method of choice to identify urease-producing bacteria. Stone cultures are best obtained by crushing the stone in saline solution and sending the fluid for analysis. In the absence of a stone culture, a urine sample should be taken from the kidney at the time of surgery.[6]

DISCUSSION

T Staghorn lithiasis has a high association with urinary tract infections. However, currently, there are reports of staghorn lithiasis growing in the absence of infection. Winoker et al evaluated 25 patients with staghorn kidney stones without infection and compared them with 64 patients with usual staghorn lithiasis (infectious stones), where they showed that hyperoxaluria was significantly higher in patients without infection, being the only significant finding of the study. Concluding that it is not clear why some metabolic stones assume the staghorn configuration.[25]

Percutaneous nephrolithotomy continues to be the treatment of choice, however it is important to take other treatment options into account in order to offer individualized management. Optimal access to the kidney is important for successful treatment. Access through the upper or lower pole calyces is suggested as it provides a straight path along the axis of the kidney and allows access to the upper pole, lower pole, and renal pelvis without excessive twisting of rigid instruments. Access should be obtained below the level of the 11th rib, when the patient is held in full expiration to minimize the risk of hydrothorax or lung injury.[3] Gücük et al performed a prospective randomized study in which patients underwent rigid nephroscopy during PCNL, with or without concomitant flexible nephroscopy. This study showed that the stone-free rate was higher in patients who underwent concomitant flexible nephroscopy, at 92.5% versus 70%.[26] El-Nahas et al conducted a study in which lithotripsy with holmium laser was compared with ultrasonic lithotripsy in the approach to staghorn stones, obtaining as a result greater safety and benefit in patients who were treated with holmium laser compared to those who were treated with holmium laser. which were treated with ultrasonic energy. Results based on patients' hemoglobin levels.[27] Xiao et al compared the perioperative and long-term results of retroperitoneal laparoscopic pyelolithotomy (RPPL) and percutaneous nephrolithotomy for the treatment of staghorn lithiasis. The stone-free rate in a single session was higher (88.2% versus 64.8%), the mean drop in hemoglobin was lower (0.4±0.3 versus 1.7 ± 0.9 g/ dL), the rate of postoperative fever was lower (5.9% vs 20.4%), but the operating time was longer (135.7±35.5 versus 101.9±41.2 min) and the total cost it was higher (5546±772 versus 3861±402 USD) in the RPPL group compared to the PCNL group (all $p<0.05$). The stone recurrence rate was similar between the groups. Concluding that in some selected cases with extrarenal and dilated pelvis, LRP can be considered as a management alternative since it was associated with low complication rates and better functionality of the affected kidney.[28] Extracorporeal shock wave lithotripsy has been used as an adjunct to PCNL. However, the development of PCNL techniques has provided a complete or almost complete removal of stone material, which has decreased the need for complementary extracorporeal shock wave lithotripsy treatment.[1]

CONCLUSION

Staghorn lithiasis is a condition that in most cases will be associated with a violation of the urinary tract. It is important to carry out an opportune diagnosis and treatment, since due to the anatomical involvement, they can cause deterioration in renal function. Simple computed tomography is a great diagnostic tool, which will also help surgical planning, managing to choose the most appropriate technique for the patient. Percutaneous nephtholithotomy continues to be the treatment of first choice; however, other techniques must be taken into account to carry out an individualized surgical treatment, depending on the clinical and anatomical characteristics of the patient, with the common goal of achieving complete stone cleaning, and with it an adequate stone-free rate.

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