Symposium

Managing caliceal stones

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ABSTRACT

The natural course of untreated asymptomatic caliceal calculi has not been clearly defined, especially in terms of disease progression, and the indications for and outcomes of surgical intervention are not precise. Caliceal stones may remain asymptomatic but, in case of migration, ureteral calculi can cause acute ureteric colic with severe complications. The decision for an active treatment of caliceal calculi is based on stone composition, stone size and symptoms. Extracorporal shock-wave lithotripsy (ESWL) has a low complication rate and is recommended by the current guidelines of the European Association of Urology as a first-line therapy for the treatment of caliceal stones <2 cm in diameter. However, immediate stone removal is not achieved with ESWL. The primary stone-free rates (SFR) after ESWL depend on stone site and composition and, especially for lower pole calculi, the SFR differ widely from other caliceal stones. Minimally-invasive procedures including percutaneous nephrolithotomy and ureteroscopy are alternatives for the treatment of caliceal stones, associated with low morbidity and high primary SFR when performed in centers of excellence.

Key words: Caliceal stones, extracorporeal shock-wave lithotripsy, percutaneous nephrolithotomy, ureteroscopy

INTRODUCTION

The natural course of untreated, asymptomatic caliceal calculi is not well known. Which patients need treatment and in what form is not precisely documented. Caliceal stones may remain asymptomatic but, in case of migration into the ureter, can cause an acute colic with severe complications.

The decision to pursue active therapy is based on general aspects as stone composition, stone size and symptoms. According to the European Association of Urology (EAU)-guidelines, the indications for an active approach are:[1]

- Stone growth
- Nephrolithiasis in high-risk patients for stone disease
- Obstruction due to the stone
- Infection
- Symptomatic stones (i.e., acute/chronic pain, hematuria)
- Stone size >15 mm or smaller, if above mentioned indications are given
- Patient's request
- Presence of the stone >2-3 years.

Besides a conservative approach (watchful waiting), there are a number of treatment options. Extracorporal shock-wave lithotripsy (ESWL) as well as minimally-invasive procedures like ureterorenoscopic or percutaneous interventions are possible. There are various factors influencing the choice of the treatment, such as stone characteristics (expected stone composition, location and size), symptoms (urinary tract infections, pain), patient factors (age, comorbidities), particular contraindications or anatomic characteristics and availability of technical expertise.[1] However, the choice of surgical intervention needs to be weighed against the morbidity and risk of complications individually.[2]

WATCHFUL WAITING

The natural course of small, non-obstructive asymptomatic caliceal stones is not defined, i.e. the risk of progression is unknown. There is no consensus on the frequency of follow-up or the surgical intervention if needed.[1] Active therapy is recommended as described in the EAU guidelines above.[1,3-5]

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The need for active intervention for asymptomatic nephrolithiasis is not defined, except in rare cases of job-related or geographic factors (i.e., pilots, missions in regions of insufficient availability of medical-care).[2] The risk of stone growth and 5-year-intervention-rates vary from 45-77%[6,7] and 48.5-83%,[6,8] respectively. Another series reported stone growth in 33% of patients with an intervention rate of 11% in 52.3 months of observation.[9]

A prospective-randomized study with asymptomatic caliceal stones <15 mm did not find any statistical advantage of ESWL over observation in terms of stone free rate (SFR), quality-of-life, kidney function and symptoms during a 2.2-year follow-up.[10] Owing to this controversial data, watchful waiting can be suggested with yearly follow-up examinations over a period of 2-3 years. Thereafter, intervention should be considered and discussed with the patient. Watchful waiting is possibly associated with the risk of potentially more invasive interventions.[1]

ESWL

As a non-invasive method with low complication rates, ESWL is an attractive therapy option for nephrolithiasis. SFR of >90% are reported.[11-13] However compared to ureterorenoscopic or percutaneous interventions, an immediate and complete stone removal cannot be ensured.[2]

The success of ESWL, measured by the SFR, depends on various factors: Effective fragmentation, effective drainage of the fragments, the stone composition (with worse results with calcium oxalate monohydrate, cystine, brushite), patient habitus (obesity) and the quality of ESWL. Fragmentation is indirectly proportional to stone size and the distance between stone and skin surface,[14] while it is directly proportional to the stone composition and density. These factors mainly influence the rate of re-intervention and SFR of ESWL.[1] Fragment expulsion depends particularly on stone location. Therefore, SFR of lower pole calculi differ extremely from other caliceal stones (37-60 vs. 80%).[2]

Modern lithotripters allow intervention without general anesthesia and they are smaller than the first generation lithotripters. However, a recent prospective-randomized study reported better outcomes with first generation (HM3) lithotripters over one of the newest generation (Storz MODULITH® SLX-F2) devices in terms of SFR, fluoroscopy time and quantity of shock waves used. Furthermore, there were less complications and re-interventions needed with the HM3-lithotripter. In all cases, either peridural-, spinal- or general anesthesia was used.[15]

Contraindications to ESWL are pregnancy, clotting disorders, urinary tract infections, kidney masses in the ESWL-area, aortic aneurysms, anatomic obstructions distally to the stones, and anatomic variations (i.e., skeletal disorders, obesity). The insertion of a ureteral stent does not influence the SFR of ESWL but reduces the risk of ureteral colics.[16] The optimal frequency of shock waves is 1 Hz.[1] Multiple ESWL-sessions improve the SFR.[2] However, there is no consensus on the maximum number of shock waves. In addition, neither the interval of multiple ESWL-sessions nor the maximum number of those sessions is defined. The success of ESWL also depends on the experience of the surgeon.[1] Sufficient analgesia promotes successful treatment by reducing thorax expansion and movements.[15] Antibiotic prophylaxis is not generally recommended, except in cases of indwelling catheters due to the increased bacterial burden.[1]

Various factors have been found to improve results and SFRs of ESWL: Inversion, mechanical percussion and diuresis lead to an increased SFR in small residual fragments.[17,18] There is no distinct data about long-term complications of ESWL like hypertension or diabetes.[19,20]

URETERORENOSCOPY

Technical advances in ureterorenoscopes (diameter <8F, improvements of optical quality) and auxiliary devices (baskets, forceps, guide wires, lasers) has led to a wide spread availability and use of ureterorenoscopy for stone treatment.[1] The introduction of flexible ureterorenoscopes with maximum flexion >270° enabled access to all calices, independent of anatomic variations or obesity.[2,21]

With ureterorenoscopy, immediate stone clearance can be ensured.[2] Apart from general contraindications like untreated urinary tract infections or anesthesiological contraindications, there are no limitations.[1] Ureterorenoscopy can be performed even under oral anti-coagulation and in cases of bleeding disorders.[22,23]

A pre-operative single-shot antibiotic dose (<24 h pre-operative) is recommended by the EAU-guidelines.[1] Fluoroscopy is needed. Access to the upper urinary tract can be facilitated by using balloon dilatators. If the intubation of the ureter ostium is not possible with a flexible renoscope, pre-dilatation by a semi rigid ureteroscope or pre-operative stenting (>7 days) with a double-J (DJ) stent will help.[24] The use of safety guide wires is recommended to facilitate ureteral stenting in cases of complications (i.e. bleeding, ureteral tearing).[1] However, ureteroscopy (URS) is also possible and safe without safety guide wires in experienced hands.[25]

The insertion of hydrophilic access sheaths facilitates ureteroscopy and provides protection against elevated renal pressures during flexible URS with multiple fragment extraction.[26] Furthermore, it may lead to higher SFRs and shorter operation duration.[27] To extract stone fragments, baskets or small forceps can be used. The use of small tip-less nitinol-baskets for the removal of fragments increases the efficiency of flexible URS in terms of fluid irrigation and flexion of instruments compared with conventional instruments. In addition, tip-less baskets reduce the risk of mucosal injury.[1] During flexible URS, tip-less Nitinol-baskets can be used with minimal impact on scope deflection and irrigation loss.[28] Ureterorenoscopic lithotripsy is most efficient with Holmium: YAG lasers which allow fragmentation of stones of all compositions. The fragmentation is also more effective than with pneumatic or electrohydraulic lithotripsy. The risk of urothelial injury is low.[1]

Relocation of stones from the lower calyx into the renal pelvis or the upper calyx facilitates fragmentation of calculi because then a semi rigid instrument can be used and the lithotripsy is not performed in flexion of the flexible instrument. This leads to an increased SFR and prevents damage of the instrument due to the manipulation of laser fibers or baskets.[29] Complete fragment extraction should always be attempted since residual fragments increase the risk of recurrent stone disease and post-operative complications.[30] Pre-operative stenting is not recommended regularly, although it possibly leads to higher SFR and lower complications rates. Post-operative stenting is recommended in patients with high risks for complications, i.e., bleeding, perforation, infections or residual stones.[1]

Overall complication rates of URS are low at 9-25%.[1] Naturally, complication rates depend of various factors and are significantly lower in high-volume centers. However, complication rates increase if all complications are classified according to the Clavien-Dindo classification.[31,32] Nevertheless, URS is altogether a safe and efficacious procedure.

PERCUTANEOUS NEPHROLITHOTOMY

PCNL is the most effective treatment option with primary SFRs of > 90%. Technical modifications have led to reduced morbidity with improved efficacy.[33-35] Complications such as extravasation (7.2%), blood transfusion (11.2-17.5%) or post-operative fever (21-32.1%) are common. However, severe complications are rare, i.e. urosepsis (0.3-4.7%), perforation of the colon (0.2-0.8%) or pleura (0.0-3.1%).[36] Comorbidities such as renal insufficiency, obesity or cardiovascular diseases increase the risk of complications.[37] High volume centers have lower complications rates and higher SFRs due to the experience.[38] However, complication rates increase if all complications are documented according to the Clavien-Dindo classification.[39,40]

Contraindications for PCNL are anesthesiological contraindications, bleeding disorders and untreated urinary tract infections, anatomic variations like atypical intestinal anatomy or skeletal disorders, which preclude a safe puncture. Tumors within the access route, malignant kidney masses and pregnancy are contraindications.[1]

Pre-operative imaging includes ultrasound or computed tomography (CT) to evaluate stone size and position and the location of surrounding organs, i.e. intestine.[41,42] A contrast medium imaging (CT or urography) is highly recommended to assess the configuration of the pelvicaliceal system and to ensure a safe access to it during the intervention.[1] Normally, PCNL is performed in the prone position. However, it is possible and in exceptional cases convenient to operate in the supine position, i.e. in cases of combined surgery (PCNL and URS).[1]

Pre-operative insertion of a ureteral catheter with balloon occlusion mechanism into the renal pelvis facilitates the puncture through dilatation and instillation of contrast into the renal pelvis. It also prevents migration of stone fragments into the ureter. Ultrasound assisted puncture, in combination with fluoroscopy, reduces radiation exposure and the risk of injury to neighbouring organs.[43] In anatomically difficult cases, CT assisted puncture techniques are described in clinical trials, for example the iPad®-assisted puncture or the Uro-Dyna-CT.[44,45] Dilatation of the puncture tract is performed using metallic telescopic dilatators, one-shot dilatators or balloon-dilatators whose effectiveness is comparable.[46]

Rigid as well as semi-rigid nephroscopes (diameter up to 28 F) allow wide operating tracts.[1] To avoid sepsis and retroperitoneal extravasation, low-pressure-systems like the Amplatz-shaft or continuous-flow-instruments are recommended.[2] Potentially, complex cases need more than one access tract. The use of flexible nephroscopes or a combined access with flexible ureterorenoscopes reduces the need of multiple access tracts.[1] Pneumatic and ultrasound lithotripters as well as Holmium: YAG lasers are in use for the intracorporeal lithotripsy.[1]

After the intervention, a percutaneous nephrostomy is usually inserted. On the one hand, the access tract is blocked to prevent bleeding and on the other hand, it ensures the possibility of a second-look-nephroscopy.[2] Indications for the insertion of a nephrostomy include residual fragments, significant intra-operative blood loss, urine extravasation, ureteral obstruction and the risk of infections due to infectious calculi. DJ-stents are generally inserted through an antegrade access to prevent obstruction in cases of residual fragments or inadequate transureteral drainage.[1] If no complications occur, the insertion of nephrostomy ("tubeless PCNL") or haemostatic drugs does not have to be performed.[47]

MINI-PCNL

To reduce the risk of access-associated complications like bleeding or parenchymal lesions, instruments with smaller access diameters (12-20 F) have been developed, originally for use in pediatric urology.[2] This so called mini-PCNL or mini-Perc seems to be associated with less morbidity compared to the standard PCNL. The advantage due to less parenchymal injury is not proved yet and benefit in adults remain controversial. However, for pediatric urology, the EAU-guidelines recommend the mini-PCNL as first line therapy for percutaneous stone removal in children.[1,48]

LAPAROSCOPIC AND OPEN SURGERY

Since ESWL and endourological techniques developed rapidly, open or laparoscopic surgery is rarely indicated.[2] The incidence declined to 1-1.5% in developed countries and from 26 to 3.5% in developing countries.[49,50] It is recommended only in rare cases in which ESWL or endourological techniques will not be able to achieve an adequate stone extraction [Table 1].[1] Laparoscopic techniques like partial nephrectomy, pyelolithotomy, laparoscopic assisted PCNL or nephrolithotomy in combination with reconstructive techniques (as for example the laparoscopic pyeloplastic) eclipse open surgery progressively.[2,51] Lower morbidity, shorter convalescence and better cosmetic results outdo the open surgery with comparable functional results.[1]

SFRS, RESIDUAL FRAGMENTS

ESWL is still recommended by the European association of urology (EAU) as a first line therapy for the treatment of caliceal stones <2 cm in diameter [Figure 1][1]. SFRs of >90% are described.[1] However, fragment passage depends very much on the stone location and especially the SFR of calculi located in the lower caliceal group differ significantly from other sites.[15] SFR of 63-70%, 21-57% and 14-33% are reported for stones <10 mm, 10-20 mm and >20 mm in diameter, respectively.[52-54] In addition, primary SFRs of multiple caliceal stones decrease considerably (44-64%).[9]

Excellent primary SFR of over 90% are reported for PCNL.[34,38,40] A recent study described higher SFR (82.5 vs. 75.1%) in specialized departments (>77 PCNL/year) than in non-specialized departments (<77 PCNL/year) [Figure 1] [1]. The complication rates are also lower (15.9 vs. 21.7%). 2/3 of those patients were treated for lower pole stones.[38]

Table 1: Indications for open and laparoscopic surgery for caliceal stones according to the EAU guidelines

Indications
Complex stone burden
Failure of ESWL and/or PCNL or URS treatment
Anatomic abnormities
Morbid obesity
In case of concurrent conditions requiring laparoscopic/open surgery
Nephrectomy in case of non-functioning kidney or partial nephrectomy in case of non-functioning lower pole of the kidney

EAU=European Association of Urology, ESWL=Extracorporal shock-wave lithotripsy, PCNL=Percutaneous nephrolithotomy, URS=Ureteroscopy

Currently, ureterorenoscopy is not recommended as first line treatment option for caliceal stones[1,2] [Figure 1][1]. However, SFR of 90.9-93.9% are described for URS. Even in cases of large stones (2.2.-3 cm in diameter) those SFR are reached within 1.7-2.3 sessions with low complication rates.[55-57] Also, in cases of multiple stones, high SFR of 92.2% (74.4) can be reached after 2[1] sessions with an average stone size of 6.6 (12) mm and 3.2 (3.6) stones.[58,59]

The literature provides only very few prospective-randomized trials which compare these treatment options.[3] A multi-center prospective randomized study compared SFR of 52 ESWL-with 55 PCNL-patients. After 3 months, ESWL patients presented with a 37% SFR compared to 95% SFR for PCNL-patients. Depending on the stone size (<1 cm, 1-2 cm, >2 cm), 63%, 21% and 14% of ESWL patients and 100%, 93% and 85% of PCNL patients were stone free.[2,54] Another multicenter study compared flexible URS (35 patients) with ESWL (32 patients) prospectively in patients with lower pole calculi <1 cm. There was no statistical significant difference in SFR (50% in URS vs. 35% in ESWL) after 3 months, although patients accepted ESWL better.[60] Eventually, all therapy modalities depend on the expertise of the surgeon and the department and this hinders the interpretation of all clinical trials.[1]

Residual fragments are a common problem after ESWL, PCNL or URS and are most likely to be found in the lower caliceal group. There is no consensus about monitoring and treatment of those residual fragments. Even complete stone removal is defined variably with some studies accepting fragments <4 mm as stone free. A multivariate analysis showed a higher incidence of residual fragments via CT than with X-ray or ultrasound.[40] With residual fragments, the risk of recurrent stone disease (heterogenic nucleation), persistent urinary tract infections and ureteral colics increases.[1] Indications for active therapy of residual fragments are similar to the indications for primary stone therapy.

The current EAU-guidelines recommend a regular follow-up for patients with residual fragments after stone treatment. The risk of progression is higher in infectious stones. Overall, 21-59% patients with residual fragments need another treatment within 5 years, independent of the stone composition. Fragments >5 mm are of higher risk for another intervention, therefore an immediate removal is recommended.[61-64] Inversion, mechanical percussion and diuresis improve expulsion of residual stones and lead to an increased SFR in small residual fragments of the lower caliceal group.[18]

CONCLUSIONS

Not every asymptomatic caliceal stone needs to be treated immediately. Even though the risk of progression and intervention increases during watchful waiting, an active approach through ESWL is not superior at short-term

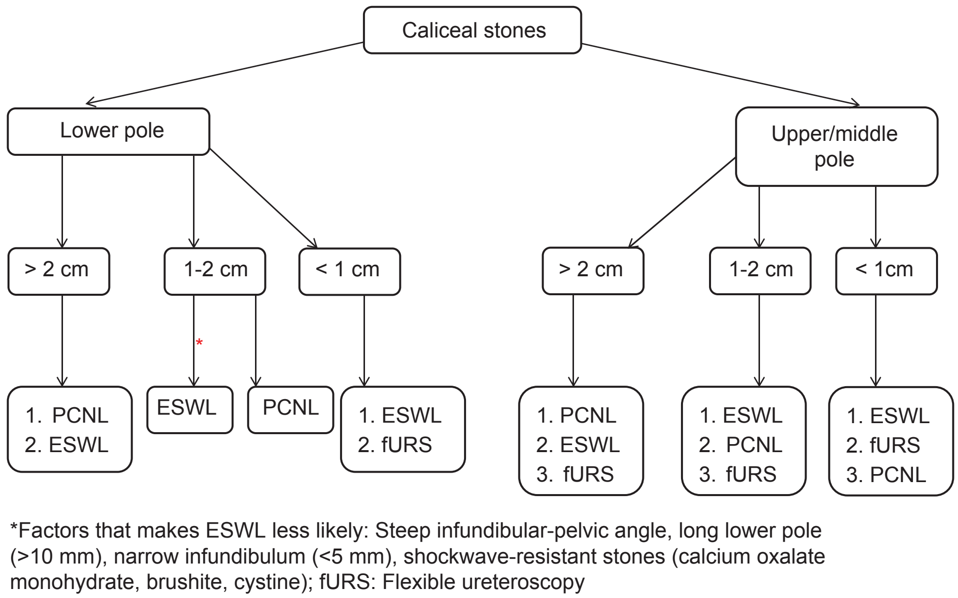

Figure 1: Treatment algorithm according to the EAU guidelines

follow-up. Watchful waiting is possibly associated with the risk of potentially more invasive interventions. The decision for active therapy is based on general aspects such as stone composition, stone size and symptoms.

ESWL, as the only non-invasive technique, shows low complication rates and good SFR. However, primary SFR for the treatment of multiple stones and stones of the lower caliceal group decrease significantly and may require multiple ESWL-sessions. An immediate stone removal cannot be achieved and it is not possible to treat all kinds of calculi with ESWL. Obese patients need to be informed of lower success rate due to a larger skin-stone-distance. Ongoing anticoagulation is a contraindication. Additionally, the success rates are highly dependent on the experience of the surgeon and the machine used.

PCNL provides immediate stone removal independent of stone composition and size. Complications such as retroperitoneal extravasation and transfusion rates are lower in recent series and depend on the expertise of the surgeon and department.

Ureterorenoscopy is increasingly becoming an alternative to ESWL with excellent primary SFR and low complication rates, especially with multiple small caliceal stones and lower pole stones. In specialized centers, even with calculi > 2 cm, SFR comparable to the ones in PCNL are achievable. However, often more than 1 session is needed and success rates are dependent on the experience of the surgeon. Advantages of URS are immediate stone removal and the possibility of intervention even in morbid obese patients and those under ongoing anticoagulation. Laparoscopic stone surgery is rarely indicated, only if ESWL or endourological techniques will not be able to achieve an adequate stone removal. There are hardly any prospective-randomized studies comparing these therapy modalities in terms of SFR, complication rate and therapy tolerance. Therefore, the choice of treatment needs to be discussed and adjusted to the patient wishes, the expertise of the surgeon and the availability of technical equipment.

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