Chapter 9
Percutaneous Nephrolithotomy and Antegrade Ureteroscopy

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Introduction

Retrograde ureteroscopy has become a mainstay in the treatment of ureteral and renal calculi. From 2000 to 2010 there was a 127 % increase in the number of ureteroscopic procedures performed in the United Kingdom and it is anticipated that a similar rise in the number of procedures will be present in the United States [1]. A recent multi-institutional study of ureteroscopy found that there was a very low overall complication rate of 3.5 % and a high postoperative stone-free rate ranging from 85 to 95 % [2, 3]. Thus, it is not surprising that ureteroscopy is gaining acceptance as the primary treatment modality for upper tract stone disease. However, there are certain circumstances when retrograde ureteroscopy is not successful, such as altered anatomy or very large stone size. In such circumstances alternate treatment options must be considered. Antegrade ureteroscopy (URS) performed through a percutaneous approach is often a useful treatment option for proximal and mid-ureteral calculi when retrograde URS is not possible. The following chapter will discuss a brief history of percutaneous ureteral stone surgery, modern uses of antegrade URS, indications for antegrade URS, a description of current technique, and a discussion of postoperative management.

History

One cannot discuss the current role of antegrade ureteroscopy (URS) without first discussing a brief history of upper tract urinary calculi and management. While Fernström and Johannson were not the first to remove a stone percutaneously, they

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did describe the initial technique for establishing a percutaneous site for stone removal in 1976 [4]. They described the slow progressive dilation of a percutaneous established tract from the kidney to the collecting system of the kidney, utilizing a Couvelaire catheter that was 0.5 mm larger in caliber. The catheter was upsized on a daily basis to enlarge the percutaneous tract and allow for eventual removal of the upper tract stone material. Following the work of Fernström and Johannson, percutaneous techniques utilizing rapid tract dilation were reported in the United States and involved the utilization of metal, flexible or balloon dilators to dilate the nephrostomy tract up to 30 French (Fr) [5–7]. In 1982, Rusnak and colleagues, describe the initial technique of rapid dilation to 30Fr and utilization of an access sheath [5]. Utilizing their own design of polyurethane dilators the authors employed an 8Fr catheter over a guide wire and dilated the tract to 30Fr. To decrease friction and improve rigidity of the dilator a Teflon™ sleeve was used that remained in place during stone extraction. The current technique for percutaneous nephrolithotomy has been improved to a point where there is a relatively low overall complication rate, Clavien grade III or higher in <5 %, and a high overall success rate with retreatment rates of approximately 15 % [8]. The introduction of the percutaneous access sheath and flexible nephroscope now allows for safe inspection of the entire collecting system including the proximal ureter, with little concern for excessive bleeding or fluid absorption.

Prior to flexible nephroscopy allowing visualization of difficult to access areas, percutaneous ureterolithotomy was described in case reports as a means to treat an impacted ureteral stone without requiring an open ureterolithotomy. Clayman and colleagues [9] discussed direct percutaneous ureterolithotomy of a patient with an impacted proximal ureteral stone creating a ureteral diverticulum preventing access by flexible nephroscopy. After obtaining percutaneous access and passing a safety wire into the ureter, an aortography needle was placed directly to the stone, the established tract was dilated to allow a 30Fr working sheath, and a direct vision ureterotome was utilized to perform the ureterotomy. A stent was left in place and removed at 6 weeks with excretory urography at that time demonstrating no extravasation. Due to the potential significant morbidity of the case it did not replace open ureterolithotomy and technological advancements soon made both techniques obsolete.

While percutaneous nephrolithotomy became regularly utilized for large renal stone and proximal ureteral stones, the first reported series of antegrade URS was described by Gumpinger and colleagues in 1985 for the management of proximal ureteral calculi which were neither amenable to extracorporeal shock wave lithotripsy nor able to be flushed into the renal pelvis for percutaneous removal [10]. Their approach utilized a lower pole access with a balloon catheter placed distally to the stone to prevent propulsion. The rigid nephroscope was then inserted and after identification of the UPJ, the axis of the kidney was tilted to allow for visualization down the ureter. The nephroscope was removed, the sheath left in place and an 11Fr rigid ureteroscope was inserted to perform ureteroscopy. Mean operative time in the 22 cases was 55 min and postoperative hospital stay was 4 days. Ureteral perforation occurred in one patient.

Soon after the initial attempt of rigid antegrade URS, flexible antegrade URS was performed by Bagley and Rittenberg utilizing a rudimentary flexible ureteroscope [11]. Flexible antegrade URS was used to identify fragments passed down the ureter during percutaneous nephrolithotomy in eight patients. Flexible antegrade URS identified one obstructing fragment in their cohort. No complications were reported. The early version of flexible ureteroscopes did not have a deflection mechanism or working port, requiring irrigant to be supplied via an ancillary catheter or irrigation sheath. As technological advancements were made with decreasing diameter, increased length, and improved deflection of fiberoptic ureteroscopes, retrograde URS became common place in urologic practice. Antegrade URS was then reserved for patients with proximal ureteral stricture disease, large impacted calculi, patients unable to be placed in lithotomy due to severe joint disease, and patients with urinary diversion and previous unsuccessful retrograde access [12].

Modern Use of Antegrade URS

Today retrograde URS has become the treatment of choice for the vast majority of small and moderately-sized distal and mid-ureteral stones (<1 cm) and yields stone-free rates >90 % in the uncomplicated stone former. Even so, antegrade URS does have utility in the modern urologist's practice and has been demonstrated to result in higher stone free rates when compared with its retrograde counterpart. Sun and colleagues performed a prospective randomized study comparing percutaneous antegrade URS with retrograde URS for large, impacted proximal ureteral calculi [13]. Patients were randomly assigned to retrograde or antegrade treatment and mean stone size was 14.6 and 14.7 mm respectively. Length of hospital stay, procedure length of time, and return to baseline activities was longer with the antegrade group. However, stone-free rates immediately post-procedure, determined by KUB and ultrasound or CT in cases of radiolucent stones, and at 1 month postoperative were significantly higher in the antegrade group (95.3 % v 79.5 % and 100 % v 86.4 %, $P = 0.026$ and 0.027 respectively). Maheshwari and colleagues also compared antegrade with rigid retrograde ureteroscopy for large (>1.5 cm) impacted upper-ureteral calculi in a nonrandomized series of 43 patients, 23 of whom underwent antegrade URS [14]. Complete stone clearance was achieved in one session in all patients using the antegrade percutaneous approach, while one session retrograde ureteroscopy was successful in only 55 % of patients, due to either stone retropulsion or secondary lower caliceal stones as verified with KUB. The authors concluded that antegrade URS can be performed in lieu of rigid retrograde URS for large impacted proximal ureteral calculi, without sacrificing stone free rates.

In developing countries with limited resources to newer technology, antegrade URS serves as a very effective means at achieving complete stone clearance without the morbidity of open surgery or the use of laparoscopy. Goel and colleagues reviewed their contemporary series of 66 patients with impacted ureteral calculi who underwent percutaneous antegrade URS for stone removal [15]. Of the 66 patients, 45 were accessed via a superior calix with nine supracostal and 21 via a middle caliceal puncture. A 26Fr rigid nephroscope was used in all cases with flexible nephroscopy used for stones which migrated distally. Complete clearance was achieved in 98.5 % of cases and all procedures were completed in a single session with one tract. Mean operative time was 47 min and aside from two ureteral perforations managed with stenting there were no other complications. The authors concluded that percutaneous removal of impacted proximal ureteral calculi in developing countries affords similar clearance rates with equipment that is more readily available, less expensive, and less fragile than flexible ureteroscopes.

Another important utilization of antegrade URS is in the setting of urinary diversion (either continent or conduit) after cystectomy or genital defects. Structural complications defined as ureteral anastomotic stricture or conduit stricture and urolithiasis are some of the most common complications following cystectomy and urinary diversion occurring in 11.5 and 15.3 % of patients respectively in a large cystectomy registry study [16]. Due to anatomic alterations it is sometimes not possible to access the upper urinary tract in a retrograde fashion once urinary diversion has been performed. Stuurman and colleagues describe antegrade flexible URS in urinary diversion patients for both stone and stricture disease [17]. There were 21 antegrade URS procedures performed, 15 of which were for stone disease. In the description of the technique patients were placed in the modified supine position, except for those with orthotopic neobladder in which the modified Valdivia position was utilized. Mean stone size was 13.4 mm and the stone free rate was 82.3 %. There were four complications in their cohort, two resulting in urinary tract infections treated with antibiotics and hematuria in the other two, which resolved spontaneously. Antegrade URS, when utilized for the proper indication, results in excellent stone free rates when compared to its retrograde counterpart.

Indications

Percutaneous antegrade URS is an ideal procedure for patients with preexisting ureteral pathology in which retrograde access cannot be obtained. Ureteral stricture disease leading to upper tract obstruction, patients with preexisting nephrostomy tube and patients with urinary diversion (Figs. 9.1 and 9.2) and reconstruction are well suited for antegrade URS in the setting of symptomatic ureterolithiasis. A large (>1 cm) impacted proximal or mid ureteral calculi or ureterolithiasis in the presence of nephrolithiasis requiring percutaneous nephrolithotomy are both excellent clinical scenarios where percutaneous antegrade URS is useful in patients without anatomic alterations. A ureteral stone located at the level of an iliac artery calcification or aneurysm can also be challenging to treat in a retrograde fashion and may be better suited for an antegrade URS approach (Fig. 9.3).

Preoperatively patients are counseled in the outpatient setting regarding the risks of antegrade URS and the typical convalescence. If a new percutaneous tract is established, overnight observation is recommended to assess for any significant

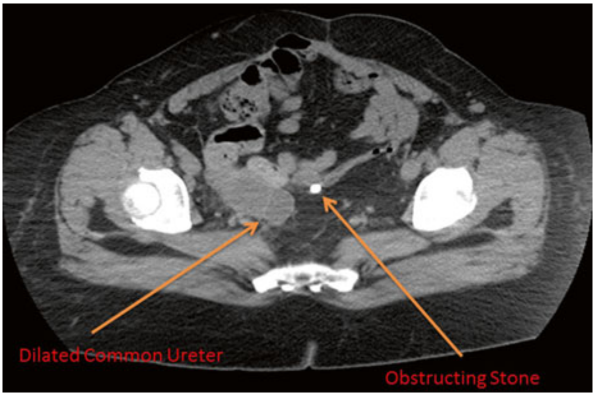

Fig. 9.1 Image of a female patient with an obstructing distal stone in the common ureter of her ureterosigmoidostomy. She was treated successfully with antegrade ureteroscopy

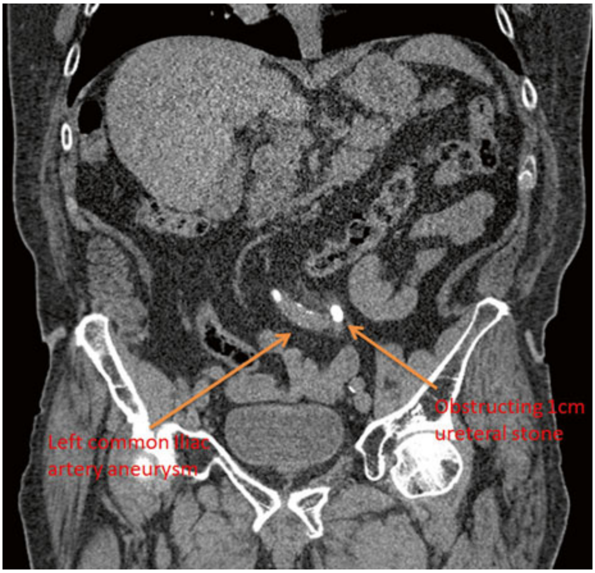

Fig. 9.2 Seventy-eight year old male with calcified common iliac artery aneurysm and 1 cm obstructing ureteral calculi

renal bleeding. If an established tract is utilized (i.e. patient already has indwelling nephrostomy tube), then the surgery may be performed as an outpatient procedure. All patients have a urinalysis with culture obtained as well as complete blood count and basic metabolic panel. All positive urine cultures should be treated prior to the procedure with culture-specific antibiotics. We recommend recent computed tomography (CT) imaging within the last 30 days to confirm stone size and location. Three dimensional CT imaging also provides information on surrounding organs and renal anatomy allowing for appropriate preoperative planning for the percutaneous renal access. If a new percutaneous tract into the kidney is created, a type and cross is obtained and patients are consented regarding the risk of blood transfusion.

Fig. 9.3 Antergrade ureteroscopy performed with the two access sheath technique. This particular patient had a large lower and upper pole stone burden in addition to an impacted ureteral stone. Thus, two renal access sheaths are in place, one for the lower pole stones and one to access the upper pole and ureteral stone. A ureteral access sheath has been advanced through the upper pole access

Equipment

To perform percutaneous antegrade ureteroscopy the surgeon will require standard equipment for both percutaneous nephrolithotomy and for ureteroscopy. We recommend a rigid nephroscope, flexible nephroscope, and flexible ureteroscopy. Percutaneous access and establishing a percutaneous access tract using a renal access sheath should be performed as previously described [18]. Once a percutaneous renal access sheath is in place there should be a working wire in the ureter. A ureteral access sheath (13 or 14Fr outside diameter) can be placed through the 30Fr renal access sheath to the level of the ureteral stone. The ureteral access sheath facilitates stone removal from the ureter in an efficient manner (Fig. 9.3). A laser lithotripter, as well as stone basket for retrieval of fragments, is recommended. An ultrasonic suction device can also be helpful to remove stone debris or blood clots that collect in the renal pelvis at the time of the procedure. A ureteral stent and/or nephrostomy tube is used at the conclusion of the case.

Patient Positioning

We prefer placement of the patient in the prone position on a C-arm capable bed with careful attention paid to pad all pressure points. If we anticipate need for retrograde access to the ureter at time of antegrade ureteroscopy, then a prone split leg position is utilized. Stuurman and colleagues placed patients in both the modified supine position with elevation of the treated side and the modified Valdivia position, in which the patient is placed in a split leg position with the treated side raised as well in order to treat patients with urinary diversions [17].

Description of Technique

An understanding of renal and ureteral anatomy is vital when attempting antegrade ureteroscopy in particular when retrograde access has failed due to distal ureteral pathology. Our current practice utilizes triangulation technique for upper-pole percutaneous access as previously described [18]. Upper pole access is preferred as it allows for a direct course into the proximal ureter. Once access is established, a 0.038-in. hydrophilic nitinol glidewire is advanced down the ureter to the level of the stone. The wire is then exchanged for a stiff workable wire and the tract is then dilated using an 8/10Fr dilating catheter and a second stiff safety wire is placed through the 10Fr dilator. The working stiff wire is then used to advance the balloon dilator into the collecting system. The tract is balloon dilated and a 30Fr renal access sheath is then advanced into the kidney. Rigid nephroscopy is then performed to confirm appropriate sheath placement. An ultrasonic lithotripter with suction capabilities is often helpful to remove any blood clot or debris that may be present in the renal pelvis. Flexible nephroscopy is then performed to inspect the entire kidney and proximal ureter. If the flexible nephroscope cannot be easily advanced to the ureteral stone then a flexible ureteroscope will be necessary to complete stone removal. In order to facilitate easy access to and from the stone with the ureteroscope it is often beneficial to place a ureteral access sheath through the renal access sheath. Placement of the ureteral access sheath to the level of the stone is performed using a 12/14 or 11/13Fr sheath advanced with fluoroscopic guidance over the stiff working wire.

The ureteroscope is then easily advanced through the ureteral sheath to the stone. Once the stone is visualized laser lithotripsy is performed utilizing the holmium laser with settings appropriate for stone fragmentation (our preference is 8 Hz and 0.8 J). Stone fragments are then removed utilizing basket extraction. After all sizeable fragments have been removed, a guidewire is advanced down the length of the ureter and URS is performed for a full inspection of the ureter to the interior of the bladder. The ureteral access sheath is removed and the kidney is inspected one last time with the rigid and flexible nephroscope to remove any debris which may have migrated proximally. Next a double-J ureteral stent is deployed under fluoroscopic guidance. We generally leave the stent indwelling for 2–4 weeks depending on the degree of stone impaction and ureteral condition.

While our practice utilizes the "double sheath" technique for antegrade URS, a single ureteral access sheath-only technique can be utilized as well. Winter and colleagues describe a "no dilation" or "minimal dilation" approach with only the 12/14Fr access sheath passed antegrade over a guidewire which has already been passed down the ureter [19]. We prefer to have a renal access sheath in place to remove proximally displaced stones and concomitant renal stones which cannot be done with the single sheath technique.

If upper pole access cannot be obtained due to patient anatomy, a mid-pole or even lower pole access can be utilized. However, if the angle for the calyx to the ureter is too great then a ureteral access sheath cannot be used. In such cases, the ureteroscope is advanced down the ureter to the level of the stone visually. The stone material can then dusted it to very fine debris to be passed, with larger fragments extracted by basket. Such a technique can be very time consuming and tedious and is only recommended if all previously described options have been deemed inappropriate.

Postoperative Management

If upper pole access is established it is our practice to perform a postoperative chest x-ray to assess for any violation of the pleural cavity. Another acceptable option would be to fluoroscopically visualize the patient's lung fields prior to cessation of the surgical procedure. The patients are then monitored for 24 h and discharged postoperative day one. Antibiotics are continued for 1 week postoperatively or longer if stone culture is found to be positive for infection.

Follow-Up

A stone culture and analysis is performed on every patient. A positive stone culture is treated with culture-specific antibiotics. All patients are scheduled for follow-up 6 weeks post procedure with a 24-h urine supersaturation study and basic serum electrolyte studies including magnesium, phosphorus, calcium and uric acid. Imaging is performed based on American Urological Association recommendations and includes KUB and ultrasound for radiopaque stones or CT for radiolucent stones (i.e. uric acid) [20].

Conclusion

While retrograde ureteroscopy remains the standard treatment for many ureteral and renal stones, there are certain clinical scenarios when antegrade ureteroscopy is necessary. In appropriately selected patients the procedure can be performed in a safe and efficient manner resulting in excellent stone-free results and minimal morbidity. Utilization of both flexible and rigid instruments as well as various sized access sheaths can simplify the procedure and improve efficiency. A "double sheath" technique allows for removal of larger stone fragments and removal of renal stones during the same procedure.

Key Points

- While retrograde ureteroscopy remains the standard treatment for many ureteral and renal stones, there are certain clinical scenarios when antegrade ureteroscopy is necessary including ureteral stricture disease leading to upper tract obstruction, patients with urinary diversion and reconstruction, and large impacted proximal or mid ureteral calculi or ureterolithiasis in the presence of nephrolithiasis requiring percutaneous nephrolithotomy.
- Upper pole access is preferred to allow for placement of ureteral access sheath.
- A “double sheath” technique allows for removal of larger stone fragments and removal of renal stones during the same procedure.

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