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Invited Review

Retrograde intrarenal surgery for renal stones - Part 1

Böbrek taşlarında retrograt intrarenal cerrahi - 1. Bölüm

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ABSTRACT

The main aim in the treatment of renal stones is to clearance of the stones completely with the least morbidity. Parallel to the improvements in technology during recent years, new flexible ureterorenoscopes and effective lithotripters such as holmium laser have been developed, thus retrograde intrarenal surgery (RIRS) has become an efficient and safe option in the management of urinary system stone disease with a gradually increasing popularity. Therewithal, innovations in auxiliary equipment such as guide-wires, ureteral access sheath and stone baskets have made this procedure more effective. With this modality, nowadays, the vast majority of renal stones can be treated successfully without need of open surgery or percutaneous nephrolithotomy. RIRS can be used as a primary treatment in patients with renal stones smaller than 2 cm, in cases with prior unsuccessful shock wave lithotripsy (SWL), infundibular stenosis, renoureteral malformation, musculoskeletal deformity, bleeding diathesis as well as obese patients. The efficiency of this procedure has been also proved in pediatric patients. In the first part of this detailed review for RIRS, history, indications and contraindications, preoperative preparation, antibiotic prophylaxis, anesthesia, surgical technique related to flexible ureteroscopes and auxiliary equipment being used, postoperative care and complications of this operation are discussed with up-to-date literature.

Keywords: Flexible ureteroscopy; kidney stone; laser lithotripsy; retrograde intrarenal surgery; ureteral access sheath.

ÖZ

Böbrek taşlarının tedavisinde temel amaç, taşları en az morbidite ile tamamen temizlemektir. Son yıllarda teknolojideki gelişmelere paralel olarak, yeni fleksibl üreterorenoskoplar ve holmiyum lazer gibi etkili litotriptörlerin geliştirilmesi ile retrograt intrarenal cerrahi (RİRC) üriner sistem taş hastalığının tedavisinde giderek artan bir popularite ile etkili ve güvenilir bir seçenek haline gelmiştir. Buna ek olarak, kılavuz teller, üreteral giriş kılıfı ve basketler gibi yardımcı teçhizat yenilikleri bu prosedürü daha etkili hale getimiştir. Bu yöntemle günümüzde böbrek taşlarının büyük çoğunluğu açık ameliyat veya perkütan nefrolitotomi gerekmeksizin başarıyla tedavi edilebilmektedir. RİRC, 2 cm'den küçük böbrek taşı olan hastalarda, ekstrakorporeal şok dalga litotripsinin (SWL) başarısız olduğu vakalarda, infundibuler stenoz, renoüreteral malformasyon, iskelet-kas deformitesi, kanama diyatezinin gözlendiği vakalarda ve obez hastalarda primer tedavi olarak kullanılabilmektedir. Bu prosedürün etkinliği pediyatrik hastalarda da kanıtlanmıştır. RİRC ile ilgili bu ayrıntılı derlemenin birinci bölümünde fleksibl üreterorenoskopinin tarihçesi, endikasyon ve kontrendikasyonları, preoperatif hazırlığı, antibiyotik profilaksisi, anestezisi, cerrahi tekniği, kullanılan fleksibl üreteroskoplar ve diğer yardımcı ekipmanları, postoperatif bakımı ve komplikasyonları güncel literatür bilgisi ile tartışılmıştır.

Anahtar Kelimeler: Fleksibl üreteroskopi; böbrek taşı, lazer litotripsi; retrograt intrarenal cerrahi; üreteral akses kılıfı.

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Introduction

With the aid of the recent technological developments, there have been rapidly increasing options in the treatment of kidney stones. Kidney stones historically treated with open surgery, are often managed recently by shock wave lithotripsy (SWL) and endoscopic surgeries. Nowadays minimally invasive modalities such as SWL, antegrade (percutaneous nephrolithotripsy (PCNL) – conventional, mini, ultramini and micro), and retrograde endoscopic interventions [ureteroscopy (URS), retrograde intrarenal surgery (RIRS)] and laparoscopic surgeries are commonly used for the treatment of kidney stones.

The most important one of the various clinical parameters that can affect the success of stone treatment is the stone size.[1] It has been shown

that SWL has a good stone-free rate (SFR) for the stones measuring up to 20 mm, and PCNL is considered as a primary treatment for the stones greater than 20 mm.[2] The negative factors affecting the SFR in SWL include the presence of lower pole calyx, acute infundibulopelvic angle (IPA), calyx neck longer than 10 mm, narrow infundibulum (≤5 mm), hard stones, and obesity. Multiple sessions and additional treatments may be needed in case of these factors.[3] Even though PCNL has higher SFRs, hemorrhage, perioperative decrease in hemoglobin and renal injury can occur if the renal parenchyma is penetrated.

Although SWL and PCNL are mentioned in the guidelines as gold standard treatment modalities for the management of kidney stones, RIRS is accepted as another treatment modality in the European Association of Urology (EAU) guidelines.[4] RIRS is more frequently used thanks to the digital improvements in flexible ureteroscopy (fURS) technology, in addition to the developments in deflection mechanism, mobility, ergonomics and durability of the equipment used. Meanwhile, with developments in auxiliary devices – such as miniaturized holmium laser fibers, nitinol baskets, guidewires and ureteral access sheath – and increase in surgical experience and compliance, higher success rates have been achieved with RIRS in the management of kidney stones. Accumulated evidence have demonstrated that RIRS can be performed for stones >2 cm.[2,5] Today, reaching the stone via a natural route and achieving a high success rate with a lower morbidity have led RIRS to become a commonly used and important treatment modality.

History

In 1964, Marshall[6] has reported the first use of fURS, and has been able to see a ureteral stone with a ureteroscope passing through a 26 Fr cystoscope. At the end of 1980s, use of flexible ureteroscopes has gained acceleration with the introduction of devices that have an irrigation channel and a flexible tip (active and passive deflection). Bagley et al.[7] published their first fURS study in 1987, thereafter Kavoussi et al.[8] reported their series including 76 fURS procedures in 68 patients in 1989. The developments in flexible ureteroscopes in this time have mainly related to decreasing the diameter of the devices and increasing the deflection angles. In 1994, Grasso and Bagley[9] reported their early-term experience with ureteroscopes with working channels of 7.5 Fr and 3.6 Fr, where they noted that no dilatation was needed in 48% of the patients due to use of a device with a narrower diameter. In 2001, a ureteroscope with 2-way deflection (270°) has been manufactured which allowed access into entire pelvicalyceal system.[10] The durability of flexible ureteroscopes has been increased, so that they can be used without any need for maintenance up to 50 cases.

With the developments in the endoscopic technology, digital flexible ureteroscope has been manufactured in 2006. However, because of its wider diameter, ureteral access sheath (UAS) has been more frequently used. Later on, Zilberman et al.[11] published their series with the use of newer digital ureteroscopes with a higher resolution and color quality that can show the anatomic structures 5.3- fold bigger than standard flexible ureteroscopes. As the improvements have emerged, it has been possible to develop new flexible ureteroscopes with a smaller caliber when compared to older conventional flexible ureteroscopes. Another development has been achieved with the addition of a second working channel that enabled an increase in irrigation power.

Yinghao et al.[12] reported the first combination of rigid and flexible ureteroscope – "the Sun's ureteroscope" – in 2010. This device is consisted of a retractable rigid shaft and a flexible tip that enable to treat both ureteral and renal stones without changing the endoscopes. In their series of 175 patients, a shorter duration of operation and a SFR of 83% have been reported.[12] Lastly, some researchers have described robotic RIRS system.[13,14] The effects of these systems on outcomes of surgery are not clear at the moment. The potential advantages of this robotic system seem to be improved ergonomics and stability of the instruments.

Indications

In the beginning, the indications of RIRS included failure of previous SWL, lower calyx stones and stones smaller than 1.5 cm. However, the limitations in the indication of RIRS has been reduced recently, where it can be used for stones smaller than 2 cm as a first-line treatment option besides SWL, and can be an alternative to PCNL for the stones in lower calyx and those greater than 2 cm. The relatively lower morbidity of RIRS has caused it to be used increasingly. Although its absolute indications have not been reported, the potential indications can be listed as below:

- Medium-sized stones that are not suitable for SWL or PCNL.
- SWL-resistant stones.
- Non-opaque stones.
- Existence of anatomic abnormalities (acute IPA, long lower pole calyx, narrow infundibulum).
- Co-existence of renal and ureteral stones.
- Need of treating bilateral renal stones successfully in a single session.
- Multiple kidney stones including nephrocalcinosis.
- Bleeding disorders.
- People who have to be treated completely stone-free (such as pilots, etc.).
- Percutaneous antegrade approach for ureteral stones in patients with urinary diversion.
- Combined or ancillary procedures following PCNL.

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- Renoureteral malformations.
- Patient habitus (obese, musculoskeletal deformities).
- Stones >3 cm (may require two or more sessions).

Retrograde intrarenal surgery is an efficient and reliable treatment method for patients with obesity, musculoskeletal deformities, renoureteral malformations, infundibular stenosis, bleeding disorders in whom other treatment options are risky or insufficient.

Preoperative evaluation

The patient has to be informed about the style, success rate and possible complications of the operation, and informed consent has to be taken. The patients are evaluated preoperatively with physical examination, routine blood tests, urine test and culture, kidney-ureter-bladder (KUB) x-ray, renal ultrasound (US), intravenous urography (IVU) and/or non-contrast computed tomography (NCCT).

Antibiotic prophylaxis

Even if prophylactic antibiotic is used, incidence of urinary tract infection (UTI) following ureteroscopy ranges between 4% and 25 percent. For this reason, use of prophylactic antibiotic is controversial with the lack of strong evidences.[4,15] According to the American Urology Association (AUA) Best Practice Policy, 1st generation cephalosporins or fluoroquinolones are generally used preoperatively, and oral antibiotics are given on postoperative 1st day.[15] Administration of prophylactic antibiotic should be considered for the patients who have a double-J (DJ) stent, ureteral catheter or nephrostomy catheter as well as for the patients with risk of bacterial endocarditis or immunosuppression.[16]

In our daily practice, we use prophylactic 1st generation cephalosporins preoperatively for the patients with a negative urine culture, where appropriate antibiotic is given according to the antibiogram for the patients with a positive urine culture.

Anesthesia

General anesthesia is frequently preferred for RIRS. With the regional anesthesia techniques like spinal anesthesia, the patient may feel pain, unwanted traumas may occur due to inadequate relaxation of the ureters or uninhibition of variable breathing movements. Zeng et al.[17] compared the patients who had undergone combined spinal and epidural anesthesia (CSEA) (31 patients) with general anesthesia (GA) (34 patients). They reported that the results in CSEA group were not worse than GA group and no conversion to GA was required in CSEA group. They concluded that the efficiency and safety were similar between two groups, while the cost was significantly lower in CSEA group. Although general anesthesia is the preferred method during RIRS, regional anesthesia can be used due to cost issues or for the patients in whom general anesthesia can be risky.

Surgical technique

The surgical technique in RIRS will probably continue to change in the future with the improvements in design of the instruments. The new instruments have the potential to increase the efficiency and cost-benefit ratio, while decreasing the complication rates.

The list of the equipment and instruments used during RIRS is given below:

- Flexible ureterorenoscope and semi-rigid ureterorenoscope.
- Cystoscope.
- C-arm fluoroscope.
- Guidewires (diameter: 0.025-0.038 inch; length: 80-260 cm).
- Ureteral catheter or dual lumen catheter.
- Ureteral dilatator.
- Ureteral access sheath.
- Holmium:YAG laser with laser fibers with different core size (200, 270, 365 μm).
- Stone basket.
- Irrigation pump.
- Contrast agent.

The procedure is performed under general anesthesia with the patient in the dorsal lithotomy position. The bladder is entered either with a cystoscope or a semi-rigid ureterorenoscope. Guidewires, ureteral stents or dilatators can be used to enter the ureter. In the traditional technique, guidewire is sent to the ureter – preferably under fluoroscopic guidance – when the ureteral orifice is seen. If desired, a second guidewire (safety wire) can be passed by the other guidewire via a cystoscope or a dual lumen catheter. A 10 Fr urethral catheter can be placed in the bladder for the drainage of the bladder during the operation.

For the first generation flexible ureteroscopes, the intramural part of the ureter had to be dilated to get access to the ureter in the vast majority of the patients, as the outer diameter of these ureteroscopes was 10 Fr. However, today, as the outer diameter of the distal part of the flexible ureteroscopes is 8 Fr, dilatation of the ureter is seldom needed. In our routine practice, after the guidewire is sent, we advance the semi-rigid ureteroscope towards the renal pelvis through the ureter under direct vision. By this way, the ureter can be evaluated for a possible stricture, a co-incidental ureteral stone can be treated, and the ureter can be dilated mechanically. After the renal pelvis is reached, the semi-rigid ureteroscope is removed, and the flexible ureteroscope is advanced either via a UAS or through the guidewire directly under fluoroscopic control. Afterwards, a 10 Fr nelaton catheter can be placed into the bladder to prevent overdistention of the bladder. All collecting system is observed under direct vision until the stone is found. Sometimes fluoroscopic vision or addition of a contrast agent can facilitate access to the stone. Especially repositioning of lower calyx stones with a basket catheter can both facilitate access to the stone and prolong the lifetime

of the flexible device. After the stone is reached, the laser fiber should be advanced if the ureteroscope can not be deflected. The stone is fragmented with the laser until clinically unimportant residual fragments are left. If stone analysis is desired, a little stone fragment can be retrieved with a 1.7 Fr or 2.2 Fr basket catheter. There is no need to place a DJ stent if the procedure is completed without any complication and the clinically insignificant residual stone fragments are left.

Instrumentation

Tendency to use RIRS in the treatment of kidney stones has risen with the technological improvements in the design of flexible ureteroscope, laser lithotripters, UAS, guidewires, stone baskets and forceps. For a successful result, the surgeon has to know the advantages and disadvantages of the equipments he/she uses.

Ureteroscope

Flexible ureteroscopes are mainly composed of fiber optic system (that provides the fiber vision and light source), deflection mechanism and working channels. Newly developed digital flexible ureteroscopes have a much higher image quality and durability as no extra light cable and camera head are needed.

Almost every flexible ureteroscope has a working channel of 3.6 Fr, which enables the irrigation and advancing of the auxiliary instruments at the same time. Dual-lumen flexible ureteroscope has two working channels with a diameter of 3.3 Fr. The limitations in irrigation and vision could have been overcome with this dual-lumen; but on the other hand, this has led to an increase in outer diameter to 9.9 Fr Available flexible ureteroscopes and their properties are shown in Table 1.

Disposable ureteroscope: PolyScope (Lumenis, Yokneam Israel) is a modular ureteroscope that is composed of an isolated optic core and a disposable 3.6 Fr working channel with a one-sided 265° active deflection and an 8 Fr outer sheath. Although the fiberoptic part does not require sterilization between the procedures, sterilization can be needed against unwanted contaminations due to undetected possible injuries in the shaft. In a recent study, no breakdown in optic part has been reported after 100 sterilization cycles.[18] With this disposable flexible ureteroscope, 89.5% success rate after the first procedure has been reported in a series of 86 patients who had upper urinary tract stone disease.[19]

Ureteral access sheath

Ureteral access sheath (UAS) has been developed with the same concept of designing percutaneous Amplatz sheath. It is being used for decreasing the intrarenal pressure during endourological procedures of the upper urinary tract, and facilitating the fURS. It has some major advantages including facilitating multiple or recurrent accesses into the kidney, and decreasing the intrarenal pressure by drainage of the irrigation fluid around the scope. Thus fURS also facilitates removal of small stone fragments by this way.[20] Various papers have shown that it decreases the operation time, protects the flexible ureteroscope, and increases the SFR.[21,22] Despite these advantages, its benefit, risk and cost should be kept in mind.[23] In the paper published by Clinical Research Office of the Endourological Society (CROES) Ureteroscopy Working Group, it has been observed that with the use of UAS, no difference in SFR existed between the groups and risk of ureteral injury or hemorrhage did not increase; while postoperative complications related to infection were reported to be decreased.[23]

Table 1. Characteristics of different flexible ureterorenoscopes

		Flexible ureteroscopes					Diameter (F)		
Company	Product	Imaging system	Ventral deflexion	Dorsal deflexion	Working channel	Tip	Shaft	Proximal	French scale test
Lumenis	Polyscope	Optical	180	0	3.6	8.0	8	8	10
Olympus Gyrus ACMI	DUR-8 Elite	Optical	270	270	3.6	8.7	9.4	10.1	10
	DUR-8 Ultra	Optical	270	270	3.6	8.6	9.36	10.1	10
	DUR-D	Digital	250	250	3.6	8.7	9.3	9.3	11
Olympus	URFP6	Optical	275	275	3.6	4.9	7.95	7.95	10
	URFP5	Optical	275	180	3.6	5.3	8.4	8.4	10
	URFV	Digital	275	180	3.6	8.4	10.9	10.9	12
Storz	FLEX-X2	Optical	270	270	3.6	7.5	8.4	8.4	10
	FLEX-XC	Digital	270	270	3.6	8.5	8.5	8.5	10
Stryker	Flex Vision U-500	Optical	275	275	3.6	6.9	7.1	7.2	10
Wolf	Cobra	Optical	270	270	Dual 3.3	6	9.9	10.3	11
	Viper	Optical	270	270	3.6	6	8.8	9	10

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Placement of a UAS can cause a decrease in ureteral blood flow causing ureteral ischemia or a direct ureteral injury during the procedure.[24] UAS can cause some peri- and post-operative complications such as mucosal laceration, ureteral perforation, urine extravasation, ureteral avulsion and ureteral stricture. Traxer et al.[24] evaluated the incidence and severity of ureteral injury due to use of UAS during RIRS in a series of 359 patients treated in two different centers. They found a rate of 46.5% for ureteral wall injury, while a rate of 13% was identified for severe injuries including the muscular layer of the ureter. Risk factors for severe injuries were identified as age, male sex and absence of preoperative stent.

Ureteral access sheath should be placed cautiously with keeping the risk of false passage and overdistention in mind. The placement should always be performed over a guidewire under fluoroscopic control. The use of a guidewire is generally advised as it stabilizes the ureter while advancing the UAS and facilitates placement of a DJ stent after the procedure.[4] An appropriate UAS should be chosen according to the flexible ureteroscope used. Attention should be paid to have no or minimal friction during the procedure. The inner diameters of the available UASs differ between 9.5 Fr to 14 Fr, while the outer diameter can be between 11.5 Fr and 18 Fr. Characteristics of UAS are shown in Table 2.[25]

The working guidewire of a new UAS, 12/14 Fr RE-Trace (Coloplast, Humlebaek, Denmark) is converted automatically to a safety guidewire. Doizi et al.[26] experienced a successful placement rate of 82.5% in a prospective study including 137 patients; and concluded that this rate was not related with male sex or existence of a preoperative stent. Another version of this UAS with a 10/12 Fr diameter is also available. In a similar way, Flexor Parallel Rapid Release UAS (Cook, Blooming, USA) has a single wire that can be used as either a working or a safety guidewire. In a study by Breda et al.[27], its overall successful placement rate was found to be 94%, while the rates were 98.5% and 82% in patients with or without a preoperative stent respectively. Preoperative stenting was found to be the only single independent risk factor.

Guidewire

Guidewires are essential items for RIRS. An ideal guidewire should be flexible, but stiff enough to allow the passage of the

Table 2. Ureteral access sheath characteristics

Company	UAS name	Inner diameter (F)	Outer diameter (F)	Length (cm)
Applied	Forte AxP	10	12–16	20 – 28 – 35 – 45 – 55
	Forte HD	12	14–18	
		14	16–18	20 – 28 – 35
	Forte deflecting	10	14	35 – 55
Bard	Aquaguide	12	14	25 – 35 – 45 – 55
		13	15	
Boston Scientific	Navigator	11	13	28 – 36 – 46
		13	15	
Coloplast	Retrace	12	14	35–45
		10	12	35–45
Cook	Flexor parallel	12	14	13 – 20 – 35 – 45 – 55
	Flexor	9.5	11.5	13 – 20 – 28 – 35 – 45 – 55
		12	14	
		14	16	13 – 20 – 28 – 35 – 45 – 55
	Flexor dual lumen	9.5	14	13 – 20 – 28 – 35 – 45 – 55
		12	17.5	
Olympus–ACMI	Uropass	12	14	24 – 38 – 54
Onset Medical	Pathway	11	14	28 – 36 – 46
		12	15	
Rocamed	RocaUS	10 (10.9)	12	35 – 45
		12	14	

UAS: ureteral access sheath

instrument at the point of obstruction without making a kink, and it can be stretched enough to avoid unwanted hydrophilic emplacement. The length of the guidewires differs between 80 and 260 cm, while their diameters range from 0.025 inch to 0.038 inch. The outer surfaces are generally covered with hydrophilic material or polytetrafluoroethylene (PTFE).

The rigidity in the body and tip of the guidewire plays a crucial role during placement. The flexible tip can maneuver around the stone and the stiff body helps to place the UAS or stent. The rigidity of the body is important for the tip to pass straight through kinkings. Additionally, rigidity changing throughout the length, lubricity and rounding of the tip are the other important factors. The combination of all these factors makes the guidewires to be used effectively and easily in special applications.

A bench-top study evaluated the stiffness, lubricity and traumatic potential of the tips of 5 different guidewires.[28] Two traditional hydrophilic guidewires were evaluated: NiCore (Bard Medical, Covington, GA, USA) and RadiFocus (Boston Scientific, Natick, MA, USA). RadiFocus was found to be safer with its more flexible tip. Although the hybrid wire U-Nite (Bard Medical, Covington, GA, USA) was more slippery, Sensor (Boston Scientific, Natick, MA, USA) had a more flexible tip and needed more effort when taking out. In theory, this makes Sensor the ideal guidewire as it causes less tissue damage during placement and more resistant to unintended pullouts. The Amplatz Super Stiff (Boston Scientific, Natick, MA, USA) was found to be the stiffest one among all 5 guidewires.

Possibility of ureteral injury exists during use of various guidewires. In a recent study, a significant benefit of safety guidewires was observed during ureteroscope placement and retraction force.[29]

Ureteral dilatator

Ureteral dilatation is used for cases in which UAS or ureteroscope cannot reach to the targeted localization because of ureteral stricture, spasm or tight ureteral orifice.

Different methods can be used for ureteral dilatation. The oldest one is the passive (mechanical) dilatation. In this method, firstly a ureteral stent is placed that dwells in situ for at least 1-2 weeks, which enables passive dilatation, and then ureteroscopy is performed in the second session after the stent is removed. Active dilatation is performed in the same session with ureteroscopy. Co-axial dilatators made of PTFE, teflon or polyethylene with gradual increasing diameters can be used for dilatation. Recently, balloon dilatators are the most commonly used ones. Each balloon dilatator has a safe inflation pressure ranging from 8 atm to 17 atm.

As the diameter of the developed flexible ureteroscopes decreased, the need for ureteral dilatation has been decreased. Sofer et al.[30] found a need for ureteral dilatation in 31% of their patients (185 of 598 patients). In a recently retrospective study, of 309 fURS cases, 20 patients needed balloon dilatation of which 17 were completed with the primary procedure. After a follow-up of 10 months, no stricture was observed.[31]

Irrigation

Enough irrigation is essential for the vision during RIRS. Flexible ureteroscopes can have either a single channel used for working and irrigation at the same time, or two channels of which one is only for irrigation. Irrigation devices are classified as passive (gravity, pressure bag) or active (pump) according to the output source of the irrigation fluid. An ideal irrigation should provide a clear vision while not causing migration of stone fragments and pyelovenous reflux. In an *in vitro* evaluation of two different active systems (foot and hand pumps), hand pump was found to cause less migration of the fragments with lower maximum irrigation pulse; but both systems were found to be similar in regards of functionality.[32] In a comparison of active and passive systems, active system achieved better vision and control while it was found to be more risky for the migration of stone fragments.[33]

Baskets

Nitinol baskets are less rigid compared to stainless steel ones; thus restricts only slightly deflection of the flexible ureteroscope. Although the working channels of the flexible ureteroscopes are generally larger than 3 Fr, baskets smaller than 2 Fr are commonly used in order to achieve maximal deflection and enough fluid flow.

A study evaluated the effects of 3 smallest baskets-namely OptiFlex 1.3 Fr, N-Circle 1.5 Fr and Halo 1.5 Fr-on deflection of ureteroscope and flow rates in Karl Storz Flex X2, ACMI DUR-8 and ACMI DUR-D flexible ureteroscopes.[34] As expected, OptiFlex with the smallest diameter had the least effect on both parameters. Basal channel flow was 70 mL/min, while it decreased to 37.9-38.2 mL/min with OptiFlex and to 29.1-30.3 mL/min with the others. Loss of deflection was 7.1-8° with OptiFlex, and 10.1-11.4° with the others.

It is easier to grab small stones in renal pelvis or calyx base with the tipless baskets.

Lithotripter

Holmium:YAG laser lithotripsy is efficient for all stones with any composition; and provides much smaller fragments than pneumatic and electrohydraulic lithotripters. The energy of holmium laser is absorbed by the fluid, so the epithelial injury is less than the electrohydraulic lithotripter.

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Holmium:YAG laser is the gold standard lithotripter for RIRS.[11] The laser fiber consists of the optical elements and plastic sheath, and causing photo-thermal reaction leads to dusting and fragmentation of the stones.[35] The fragments can be retrieved with basket or very small fragments can be left to spontaneous clearance in the form of dusts. Fragmentation is more appropriate for the stones >10 mm, as dusts worsen the vision and it may be difficult to find the fragments. In dusting technique, stones not located in the middle or upper calyx should be delivered to these locations with a basket; thus, the lifespan of the flexible ureteroscope would be prolonged while the vision would be kept unaffected from the dusts.

The power of holmium laser is generally set at 0.5-1.2 Joule and 5-15 Hertz (10 to 15 Watt). Moreover, the settings can be changed according to the desired lithotripsy method, and the surgeon can perform the dusting technique by increasing the frequency while maintaining the same energy. The diameters of the laser fibers used for RIRS range between 200 and 365 μm. The irrigation and deflection would be less affected with smaller diameter (200-270 μm) RIRS, besides it has the same fragmentation effect compared to thicker fibers.

Postoperative care

If a DJ stent has been placed at the end of the operation, it is generally left in situ for 3-10 days postoperatively. In case of ureteral injury, the patient should be stented for a period of 3-6 weeks. A KUB x-ray can be taken within the first 24 hours to evaluate the early postprocedural results, however, normal evaluation would be performed after 1 to 2 weeks, postoperatively. Small stone fragments (<4 mm) generally fall out after the stent is taken out with the help of the passive dilatation performed with a DJ stent. A postoperative examination is advised to evaluate residual stone(s) and silent obstruction.[36] Secondary silent obstructions can be observed due to ureteral edema, trauma or stricture, and may cause renal insufficiency, if untreated. Nevertheless, some study groups do not advise routine postoperative evaluation if there is no perforation during surgery or no history of known stricture or impacted stone.[37] Evaluation for the success of the operation is generally performed in the 4th to 6th postoperative weeks or 4-6 weeks after the stent is removed.

Preoperative double-J stent insertion

Preoperative ureteral stents are generally used in cases of UTI, aiming to preserve renal functions, to help the surgeon to perform the operation in an elective session while relieving the pain in cases with ureteral abnormalities that do not permit passage of the ureteroscope or in cases of emergency. Other indications can be facilitation of the insertion of UAS and they can be also used for the management of previous unsuccessful RIRS attempts due to ureteral stricture. Common use of preoperative stenting in pediatric population for passive dilatation prior to ureteroscopy has been also published.[38] EAU Guidelines state that preoperative stenting is not necessary prior to ureteroscopy.[4] Nonetheless, the positive effects of preoperative stenting in SFR and in decreasing complication rates have been mentioned by some authors.[38] The use of preoperative stenting for passive dilatation prior to RIRS to facilitate the passing of UAS or flexible ureteroscope has been also reported.[39] However, this stenting has its own morbidities. Irritative urinary symptoms, bacteriuria, fever as well as sexual dysfunction can be seen.[40] In the study where Mahajan et al.[41] searched the results of the cases of RIRS performed with (double sessions) or without stenting (single session), it was reported that successful results were achieved with single session, and SFR, morbidity and complication rates were not affected with single session procedure.

Some other authors have also published that preoperative stenting increased SFR, and decreased the duration of operation and also the cost for big stones.[42,43] However, the use and effects of preoperative stenting have still controversies as the patient has to undergo a separate procedure and may experience inconveniences due to the DJ stent. In the CROES-URS study, it was stated that the duration of the operation was longer, the SFR was higher, and the rate of intraoperative complication was lower in the group with preoperative stenting.[44] For the patients with preoperative stenting, RIRS is performed at least a few weeks after the procedure.

Postperative double-J stent insertion

The purpose of postoperative stenting is to prevent hydronephrosis, pain and ureteral stricture, and to facilitate the healing process and the passage of the stone fragments. Postoperative stenting is necessary in cases of mucosal edema and hemorrhage, epithelial injury, ureter perforation and solitary kidney.

In addition to its disadvantages such as prolongation of the operation, need for an extra procedure to take it out, increased symptoms (dysuria, pollakuria, frequency, urgency, suprapubic or flank pain, fever) and decreased quality of life, minimal benefit was reported in regards of SFR and prevention of stricture formation.[45]

In a study where the complications were assessed in patients undergoing RIRS with UAS insertion, no difference was found between postoperatively stented group and non-stented group, while postoperative pain was found to be lower in the stented group.[46] In a series of 319 uncomplicated patients undergoing RIRS without previous stenting, 11.9% of the them needed urgent stenting; and male sex and stone located in the proximal ureter were found to be risk factors.[47] Ozyuvali et al.[48] reported that no stenting was needed after RIRS as it increased the cost, morbidity and operation time in their study including 162 renal units. On the other hand, they found higher postoperative pain

scores in patients with stones larger than 15 mm or located in renal pelvis. There is no consensus for optimal duration of stenting. In one study, an increased risk for fever and flank pain has been identified for stenting more than 15 days.[49]

Is a safety guidewire necessary?

A safety guidewire is kept in the ureter and collecting system during ureteroscopy so that it prevents loss of access during stone manipulation, and enables to place a DJ stent in case of a perforation or after the procedure completed. Some question marks have been appeared whether a safety guidewire should be used or not as the experience in fURS has increased. Although some centers report routine use of a safety guidewire, nowadays it is not routinely used except in some specific cases.

Dickstein et al.[50] have performed 305 RIRS in 246 patients (59 bilateral procedures) with complicated and non-complicated outcomes. A safety guidewire was used in 35 complicated cases that were defined as those having concomitant obstructing ureteral stones requiring treatment, an associated encrusted ureteral stent, or difficult access secondary to a large stone burden (steinstrasse or staghorn) or aberrant anatomy (pelvic kidney, urethral/ureteral stricture, ileal loop, suprapubic tube, limb contractures). No intraoperative complications, including loss of access, ureteral perforation/avulsion and need for percutaneous nephrostomy tube were observed when a safety guidewire was not used. As a result, in this relatively big cohort, the authors concluded that there was no need to use a safety guidewire in routine cases.

Contraindications and complications

Except an untreated UTI and other anesthesia contraindications, no specific contraindication exists for fURS.[4] RIRS can be performed in all patients including especially the ones in whom SWL or PCNL is contraindicated or not suitable. With the improving technology and increasing use and experience, more procedures are being performed with less morbidity. Its complications can be listed as hemorrhage, intrapelvic hematoma, mucosal injury, ureteral perforation and avulsion, UTI and sepsis. Overall complication rates remain low with most complications being minor and easily managed.

In the prospective URS study of CROES, among a total of 11.885 patients, 1.781 (15%) underwent only fURS where 10.7% had a combined treatment with flexible and semi-rigid URS.[51] Overall postoperative complication rate was found to be 3.5%, which were mostly (2.8%) grade 1 and 2 according to Clavien-Dindo classification. Only 0.2% of the patients needed blood transfusion, and 5 mortalities were reported within the first 30 days postoperatively due to sepsis, pulmonary embolism, multi-organ dysfunction and cardiac reasons. Besides, 8.4% of the patients re-admitted to hospital during the first 3 months postoperatively with flank pain and discomfort mainly due to indwelling ureteral stent. No difference was found in regards of postoperative complications and readmission rates between semi-rigid and flexible URS groups.[52]

Oguz et al.[53] reported rate of intraoperative complications as 30.4% according to modified Satava classification system. Grade 1, 2a and 2b complications were documented in 15.9%, 5.6% and 8.9% of the patients respectively, where no grade 3 complication was observed.

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