Symposium

Ureteroscopy: The standard of care in the management of upper tract urolithiasis in children

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ABSTRACT

Objectives: Advances in technology and the continued evolution in the design of ureteroscopes now permit a primary endoscopic approach to the upper urinary tract of pediatric patients on a routine basis to treat a diverse group of conditions that include urolithiasis, hematuria and strictures. The purpose of this review article is to demonstrate that ureteroscopic lithotripsy is now to be considered the standard of care in the management of upper tract urolithiasis in the pediatric patient, replacing shockwave lithotripsy (ESWL) as the first line of therapy. Additionally, the article will discuss the available endoscopic equipment and the lessons learned over the years to optimize the success of these procedures in children.
Materials and Methods: A systematic review of articles written about ureteroscopy (URS) in the contemporary urological literature (1990–2009) on PubMed was undertaken. The success rates and complications of pediatric ureteroscopic procedures were abstracted from the identified publications and the results were tabulated and compared with the success rates of shockwave lithotripsy.
Results: In over 832 URS cases, there was a 5.9% complication rate and a stone-free rate of 93.4%. The stone-free rates of URS are superior to those obtained with the published success rates with ESWL of 80.3% in 1,839 cases.
Conclusions: The safety and outcomes of ureteroscopic lithotripsy in the management of pediatric urolithiasis now justify that this treatment modality be considered the standard of care and first line of therapy in the management of children who present with upper tract stones.

Key words: Pediatrics, lithotripsy, ureteroscopy urolithiasis

INTRODUCTION

There are a variety of treatment options that the urologist can offer the pediatric patient who presents with an upper tract stone*, including:

- Extracorporal shockwave lithotripsy (ESWL)
- Percutaneous nephrolithotomy (PCNL)
- Ureteroscopy (URS)
- Open surgical procedures (Pyelolithotomy, ureterolithotomy). *(For the purpose of this article, we define upper tract stones as any stone located within the renal collecting system or ureter.)

Open surgery for upper urinary tract stone disease has largely fallen out of the mainstream of therapies, with the non-invasive (ESWL) and minimally invasive (URS and PCNL) options being the preferred interventions for the majority of patients (both adult and children).

URS has now become part of the standard armamentarium of the urologist treating a pediatric patient. The earliest documented instance of an ureteroscopic procedure was interestingly performed in a pediatric patient by Drs. Young and McKay in 1929 on a 2-week-old baby with posterior urethral valves.[1] They used a pediatric cystoscope to perform URS of the dilated ureters. However, it was only after Drs. Shepherd and Ritchey published their respective papers on pediatric URS in 1988 that this technique gained widespread acceptance by pediatric urologists.[2,3]

Advances in the design of ureteroscopes and ancillary instruments over the past 20 years have resulted in miniaturization and increased durability of the small caliber rigid, semi-rigid and flexible ureteroscopes required for use

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in pediatric patients. Enhancements in video technology coupled with improved optics have enhanced the ability of the urologist to evaluate and treat the pediatric urinary tract in even the smallest of patients.

The purpose of this study is to determine whether the safety and efficacy of URS now warrant it being considered the standard of care and the first line of therapy in the management of pediatric urolithiasis. An additional goal of this paper was to document the various endoscopic instruments, techniques and recommendations described in the literature to optimize the success of URS in pediatric patients.

MATERIALS AND METHODS

A systematic review of the contemporary urological citations was conducted using the National Library of Medicine (PubMed) search engine. We included only those papers that discussed original series of patients in this review. Demographic information, including patient age, gender, presenting symptoms, number of URS procedures performed and stone-free rate, were abstracted from the papers reviewed. The data are presented in Table 1.

Additionally, information about endoscopic instrumentation used by the authors and currently available was documented from the papers and also from the manufacturers' website. This information is presented in Table 2. It is intended that this serve as a reference for practicing urologists, enabling them to be aware of the type of instrumentation available for use in the care of pediatric patients.

RESULTS

A total of 27 papers that met the inclusion criteria for this review were identified and the data were abstracted. Over the past 20 years, the results of 832 pediatric patients (mean age, 9.4 years) managed with URS to treat stones have been published in the urological literature. In the same time frame, there were a total of 21 papers published discussing the results with ESWL, including a total of 1,839 patients (mean age, 7.9 years). The success rate of URS is 93.4% (compared with 80.3% for ESWL). The complication rate associated with the URS procedures is 5.9% (compared with 8.4% for ESWL). Common complications for URS included ureteral perforation requiring stent placement and urinary tract infection (UTI) (there was a very low incidence of ureteral strictures reported, <1%), whereas for ESWL, the complications included hematuria, colic, steinstrausse and UTI.

In this systematic review of the literature, URS is shown to be safer and more efficacious than ESWL in the management of pediatric urolithiasis. The experience with URS is truly global, with authors from developed and developing countries reporting their experiences with this surgical modality in pediatric patients.

DISCUSSION

The management of pediatric urinary calculi has evolved in pace with the technological advances of urological endoscopes and instruments. The introduction of small caliber, actively deflectable flexible ureteroscopes has revolutionized the applicability of pediatric endoscopy – both diagnostic and therapeutic.

Over the past 20 years, endoscopic lithotripsy has gained international acceptance as a safe and efficacious alternative to ESWL in the management of upper urinary tract pediatric urolithiasis. Table 1 summarizes the body of literature that addresses pediatric URS published in the past 20 years. These data suggest that ureteroscopic lithotripsy is an acceptable treatment modality for the management of pediatric urolithiasis. A review of our experience with URS in pre-pubertal children (age <12 years) demonstrates that the outcomes in terms of efficacy of therapy and rate of complications were similar, if not better, than those reported in the adult URS literature.[4,5]

While ESWL has historically been the treatment of choice for upper tract stones in children, URS has been shown to be more efficacious at obtaining a stone-free rate in many series. In 2005, De Dominicis reported a 94% stone-free rate with URS in children (as compared with 43% with ESWL).[6]

The decision to use pre-operative stenting or a ureteral access sheath in order to facilitate access to the proximal ureter or renal pelvis rests with the treating urologist and depends on the experience of the surgeon and the type of endoscopic instrumentation available. The following sections of this article discuss the instrumentation available for use in the pediatric patient and suggestions to optimize outcomes in the URS management of urolithiasis in children.

PEDIATRIC URETEROSCOPIC INSTRUMENTATION

Rigid, semi-rigid (4.5 Fr) and flexible (6 Fr) ureteroscopes are now available for use in the pediatric patient. Improved design of the scopes and fiber-optics have allowed for the progressive reduction in the outer-sheath caliber while maintaining a reasonably large working channel. This allows for the introduction of a variety of instruments (i.e., wires, EHL probes, laser fibers, forceps, graspers and baskets) during the procedure. (Table 2 for a listing of endoscopic scopes and instrumentation for use in the pediatric patient.) One should bear in mind however that currently available flexible ureteroscopes that are smaller than 8 Fr in outer diameter are very delicate instruments. Clinical studies have shown that urologists should expect

Table 1: Outcomes of pediatric ureteroscopic lithotripsy over the past 20 years

Authors	Number of patients treated (Mean age of patients)	Location of stone	Success rate*	Complication
Caione *et al*.[17]	7	Ureter	100% stone free three patients had associated renal calculi that were treated with ESWL	None
Thomas *et al*.[11]	16	Ureter	100% stone free	(1/16) Transient grade 2/5 VUR
Scarpa *et al*.[18]	7	Ureter	100% stone free	None
Shroff *et al*.[19]	13	Renal pelvis and ureter	100% stone free	(4/13) Aspiration pnemonia, ureteral stricture, urinary retention
Smith *et al*.[20]	11	Distal ureter	100% stone free	None
Kurzrock *et al*.[21]	17	Renal pelvis and ureter	100% stone free	(2/17) Post-operative UTI
Minevich *et al*.[22] Minevich *et al*.	7 (11 years) 58 (7.5 years)	Distal ureter Renal pelvis and ureter	87% stone free	None (1/58) 1.3% ureteral stricture
Jayanthi *et al*.[23]	12	Distal 1/3rd of ureter	91.6% stone free	None
Reddy *et al*.[24]	6	Renal pelvis and ureter	100% stone free	(2/6) Both complications related to percutaneous renal access; caliceal diverticulum and ureteral perforation
Wollin *et al*.[25]	18	Renal pelvis and ureter	100% stone free	(1/18) Prolepsis
Van Savage *et al*.[26]	17 (12 years)	Ureter	88% stone free	(2/17) Inability to pass ureteroscope, ureteral perforation
Bassiri *et al*.[27]	66	Ureter	88% stone free	(3/66) Pyelonephritis
Schuster *et al*.[28]	25	Renal pelvis and ureter	100% stone free	(2/25) pyelonephritis post-operative pain
Thomas *et al*.[29]	29 (7.8 years)	Renal pelvis and ureter	90% stone free	(1/29) 2.9% Extravasation of contrast
Tan *et al*.[30]	23 patients (9.1 years)	Renal pelvis and ureter	95% stone free	(1/23) 4.3% Febrile UTI
De Dominicis *et al*.[6]	17 patients	Ureter	94.1% stone free	0
Herndon *et al*.[31]	27 patients (11 years)	Proximal ureter – 3.7% Mid-ureter – 11.1% Distal ureter – 85.1%	96% stone free	(2/27) 7.4% Extravasation Ureteral perforation
Lesani *et al*.[32]	24 patients (10.7 years)	Renal pelvis and ureter	100% stone free	0
Singh *et al*.[33]	8 patients (9.3 years)	Renal pelvis and ureter	100% stone free	0
Smaldone *et al*.[34] Cannon *et al*.[35]	100 patients (13.2 years) 21 patients (15.1 years)	Renal pelvis – 6% Upper pole – 10% Lower pole – 17% Proximal ureter – 19% Mid-ureter – 11% Distal ureter – 37% Lower pole of kidney	91% stone free 76%	(5/100) 5% Ureteral perforation Extravasation Ureteral stricture – managed with ureteral reimplantation
Corcoran *et al*.[36]	47 (9.4)	Renal	88%	9 (ureteral perforation)
Koura *et al*.[37]	20 (5.2 years)	Proximal ureter – 10% Mid-ureter – 20% Distal ureter – 70%	90% stone free (100% with 2nd Rx)	(1/20) 5% Pyelonephritis
Tanaka *et al*.[38]	50 patients (7.9 years)	Intra-renal calculi	58% stone-free rate	0
Dave *et al*.[39]	19 patients (6.9 years)	Intra-renal calculi	80% stone-free rate	(2/19) 10% 1 – ureteral perforation 1 – urinoma
Kim, SS *et al*.[40]	167 Pts (5.2 yrs)	Renal Pelvis and Ureter	97% stone free rate (100% for stones less than 10 mm)	0

*(some patients may have received more than one procedure to achieve the final stone-free outcome)

Table 2: Suggested pediatric endourologic (ureteroscopic) equipment

Semirigid uretero-renoscopes
- Karl Storz: 7.5 Fr/9 Fr tapered scope with 3.5 Fr and 2.4 Fr lateral working channels
- Five Star Medical: 7 Fr/9 Fr tapered scope with 3.2 and 2.3 Fr working channels
- Karl Storz: 7 Fr scope with a 3.5 Fr working channel
- Olympus: 6.4 Fr/7.8 Fr tapered scope with a 4.2 Fr working channel
- Gyrus ACMI: 6.9 Fr scope with two working channels, 3.4 and 2.3 Fr
- Richard Wolf: 6 Fr/7.5 Fr tapered scope with a 4 Fr working channel
- Richard Wolf: 4 Fr/6.5 Fr tapered scope with a 3.3 Fr working channel

Flexible scopes
- Gyrus ACMI: 8.7 Fr scope with a 3.6 Fr working channel
- Karl Storz: 7.5 Fr scope with a 3.6 Fr working channel
- Richard Wolf: 7.5 Fr with a 3.6 Fr working channel
- Richard Wolf: 7.4 Fr/9 Fr with a 4.5 Fr working channel
- Gyrus ACMI: 7.2 Fr scope with a 3.6 Fr working channel
- Olympus: 6.9 Fr/8.4 Fr with a 3.6 Fr working channel
- Karl Storz: 6.7 Fr/7.5 Fr with a 3.6 Fr working channel

Guide wires
- SurgiMedik: 0.035 inch, 145 cm Bentson TFE-coated (8–15 cm) floppy-tip guide wire
- Gyrus ACMI: PTFE-coated guide wires 0.025–0.038 inch x 150 cm
- Terumo Medical Corp: Hydrophilic Glidewire, 0.018–0.038 inch x 150 cm (3 cm flexible tip angled or straight tip)

Catheters
- Cook Urological: 10 Fr dual-lumen access catheter
- Microvasive ureteral catheters 3–8 Fr
- SurgiMedik: Open tipped ureteral catheters 3–8 Fr

Ureteral dilators
- Applied Medical Resources: ureteral access dilator sheath (12–16, 14–18 and 16–18 Fr)

Percutaneous access dilators
- Cook Urological: Mini-Perc (Docimo) entry set

Stents
- Cook Urological: “C” flex stent 3.7 Fr (0.028 inch wire)
- Cook Urological: polyurethane stent 4.0 Fr (0.025 inch wire)
- Cook Urological: Sof-flex stent 3.0 Fr (0.025 inch wire)
- SurgiMedik: Surgisoft stent 4.5–7 Fr

Stone baskets
- Cook Urological: Nitonol tipless stone extractor (2.2–3.2 Fr)

(please note that this is not meant to be a complete product listing; rather, it is only a sampling of the available equipment for pediatric use)

between six and 34 uses before the ureteroscope has to be serviced/repaired. In order to maintain the ability to provide care for pediatric patients in a timely manner (24 hrs a day/7 days a week/365 days a year), the urologist should have in place an agreement with their place of service (private hospital/teaching hospitals) to provide adequate institutional resources to keep a variety of operational endoscopes available for use.[7]

RECOMMENDATIONS TO OPTIMIZE THE OUTCOMES OF URS IN THE PEDIATRIC PATIENT

While these procedures are quite similar to adult URS procedures, in that the basic endoscopic principles should be observed, there are enough differences that warrant a discussion of the subtleties of pediatric URS.

PREPARATIONS FOR PEDIATRIC URETEROSCOPY

A detailed medical history should be obtained, with special emphasis on past genitourinary conditions and/or surgery (e.g., history of previously diagnosed ureteral duplication, history of prior ureteral reimplants or Deflux® injection). This information will aid in deciding the appropriate method for gaining access to the patient’s upper urinary tract.

The relative contraindications for URS include:
- Staghorn stones in patients with recurrent stones (consider PCNL for these patients)
- History of previous ureteral surgery, i.e. cross-trigonal ureteral reimplantion. While it is not impossible to proceed with URS in these patients, it may take some modification of the procedure to achieve a successful outcome, e.g. use of an angled glidewire to access the ureteral orifice and a super stiff Amplatz wire to straighten the ureter to facilitate the passage of the ureteroscope
- History of previous bladder surgery, i.e. bladder neck reconstruction

Pre-operative imaging studies to be obtained prior to URS include:
- Abdominal ultrasonography
- Plain film of the abdomen (KUB)
- Voiding cystourethrogram (VCUG) – not always necessary in routine stone-forming children but occasionally helpful, especially in a child with history of vesicoureteral reflux (VUR) and/or bladder surgery

Optional studies include intravenous pyelogram, computerized tomography (CT scan) and radio-isotope studies (Lasix renogram). A retrograde pyelogram is usually performed at the time of the ureteroscopic procedure. These images serve as a road map for the endoscopic procedure.

Avoid using water as the irrigant as there have been anecdotal reports of pediatric patients absorbing significant amounts of water into their circulation and developing severe intravascular hemolysis and hyponatremia, resulting in seizures and even death. The preferred irrigant is normal saline warmed to body temperature to avoid potential hypothermia during prolonged procedures – limiting the procedure to 90 min also aids in the prevention of these complications.

Extra caution must be observed when operating on patients with an increased incidence of latex allergies, such as patients with Spina Bifida, bladder exstrophy or a history of complex surgical reconstruction of the lower urinary

Table 3: Various energy sources for intracorporeal lithotripsy via ureteroscopy

Energy source	Holmium laser (trimedyne, gyrus ACMI and coherent lasers)	Swiss lithoclast (EMS Medical)	EKL (electrokinetic lithotripsy) (Olympus)	EHL (electrohydraulic lithotripsy) (Gyrus ACMI)	Ultrasonic lithotripter (Gyrus ACMI)
Description	2140 nm tunable laser	*In situ* ballistic lithotriptor	*In situ* ballistic lithotriptor	Intracorporeal shockwave lithotriptor	Intracorporeal ultrasonic lithotripter
Mode of action	Plasma energy-created cavitation bubble and direct vaporization	Ballistic lithotriptor (similar to a pneumatic jackhammer). The frequency of the probe is 12 Hz	High-energy magnetic fields are used to propel an impactor that fragments the calculi. The frequency of the probe is 15–30 Hz	Spark gap at the tip of the fiber heats up the irrigant and creates a hydraulic shock wave that fragments the stone (50–100 sparks/s)	Oscillating burr tip probe disintegrates the stone. The probe is driven by an ultrasonic generator (25,000 oscillations/s)
Mode of delivery to stone	Silica quartz fibers, non-contact laser	Direct percussion of the stone via rigid or tapered semiflexible probes	Direct percussion of the stone via a rigid probe (has to be used with an offset ureteroscope)	The electrical discharge is passed down an insulated probe to create a spark at the tip	Direct contact of the stone via rigid probes
Size of fiber or probe	200, 400, 600 and 1000 m	2.4, 3, 4.8, 6 and 9.6 Fr	Five probe sizes ranging from 0.8 mm to 3.5 mm	1.9, 3, 5 and 9 Fr	4.5 Fr ureteral probe and 3.8 mm renal probe
Limitations	Operative time can be long with large stones	Risk of proximal stone migration (can be decreased with the use of the Lithovac™ suction device [4.8, 10.5 and 12 Fr suction tubes])	Cannot be used with a flexible ureteroscope. Inability to fragment very hard stones (calcium oxalate monohydrate)	Narrowest of the safety margins of all the lithotrities. High incidence of ureteral injury	Inability to fragment hard stones (calcium oxalate monohydrate). Large caliber of the probes
Complications	Laser can damage the endoscope and wires	Damage to the urothelium. Vibrational damage to the endoscopes with repeated usage	Damage to the urothelium. Vibrational damage to the endoscopes with repeated usage	Injury to the soft tissues	Injury to the soft tissues
Advantages	Extremely versatile lithotrite that can be used with most endoscopes and can treat all types of stones. Produces small fragments	Simplicity, ease of use and lack of disposable components. Least amount of trauma to adjacent tissues	Simplicity and ease of use. Least amount of trauma to adjacent tissues	Even the smallest of EHL fibers can be used to fragment the hardest of ureteral calculi in most instances	Quickly fragments large stones and removes the debris in a single process

tract. Latex allergy has become an important health issue for not only the above-mentioned group of patients but for all health care providers. Symptoms of an allergic reaction are varied, including any of the following: watery and itchy eyes, sneezing, coughing, urticaria, anaphylaxis and cardiac arrest.[8] It is preferable to have the cystoscopy suite designated as a latex-free environment to avoid any anaphylactic complications. At our hospital, the surgical complex (same-day surgery area, operating rooms and the post-anesthesia care unit) is entirely latex free. We have also designated a group of healthcare professionals whom we can consult at any time (24 hrs a day/7 days a week/365 days a year) to clarify any issues related to latex precautions. Recommendations for instituting a latex-free environment in the operating room are available at the following websites:

- www.aana.org/crna/prof/latex.asp
- www.aae.org/latex.html
- www.sbaa.org/Latex.htm

ANESTHETIC CONSIDERATIONS

The pediatric patient should be under general anesthesia for all endoscopic procedures. In the rare instance of a child with impaired sensation, i.e. Spina Bifida, depending on the sensory level and the age of the patient, monitored anesthesia care might also be considered. All patients should receive intravenous antibiotic prophylaxis at the time of the procedure.

As is the case with all cystoscopic procedures in the pediatric patient, it is important for the anesthesiologist to bear in mind that urethral stimulation can precipitate laryngospasm. Children with high spinal cord (e.g., cervical and/or upper thoracic level) lesions may also exhibit symptoms of autonomic dyssreflexia when the bladder is overfilled. This is a medical emergency and should prompt immediate bladder drainage and administration of anti-hypertensive medication if necessary.

INTRA-OPERATIVE RADIOGRAPHIC IMAGING CONSIDERATIONS

Most pediatric endoscopic procedures are performed with the assistance of mobile "C" arm fluoroscopic imaging units. Significant improvement in the intra-operative imaging of these patients can be achieved by actually performing these procedures in the interventional radiology suite, which usually have "State-of-the-Art" rotational "C" arm capability. Care should be taken to ensure that the radiation exposure to the child during the procedure is minimized as there is now a well-documented relationship of radiation dosimetry and the development of secondary malignancies.[9]

PEDIATRIC PATIENT POSITIONING

Pediatric patients under 1 year of age can be adequately positioned for flexible URS in an open leg posture using padded leg boards that extend from the table. The older pediatric patients can be positioned in the standard lithotomy position. All pressure points need to be adequately protected to prevent nerve injury or breakdown of the skin and muscle, which occurs more readily in children (especially in prolonged procedures).

Intra-operative positioning can be challenging for children who have certain musculoskeletal conditions that cause osteopenic bones, stiff or immobilized joints and muscular contractures.
These disease conditions include:

- Arthrogryposis (amyoplasia)
- Cerebral palsy (spastic diplegia or quadriplegia)
- Spina Bifida (myelomeningocele)
- Multiple pterygium syndrome (Escobar syndrome)

These patients are at an increased risk of iatrogenic fractures and/or dislocation of their lower extremities or hips. Antegrade ureteral access might need to be considered in the urological management of these patients.

PEDIATRIC ENDOSCOPIC ANATOMY

The average diameter of the pediatric ureter varies from 2 to 5 mm (there is a wide range, depending on the age and size of the patient). There are four sites of natural narrowing of the luminal diameter of the ureter.
These include:

- the ureteral orifice
- the intramural ureter
- the region of the ureter that crosses the iliac vessels
- the uretero-pelvic junction (UPJ)

There remains a concern that aggressive dilation of the ureteral orifice and the intramural ureter will increase the risk of developing post-operative VUR.[10] Shepherd *et al*. have shown that dilation of the ureter up to 12 Fr did not result in the development of VUR post-operatively in their series of patients.[2] Voiding cystograms performed in pediatric patients after URS procedures have shown that the incidence of transient low-grade (grades 1–2/5) VUR is as high as 15% in almost all of the patients the VUR resolved spontaneously with conservative management and rarely caused any symptoms.[2,11]

URETEROSCOPIC ACCESS

Factors that determine the route of URS access (retrograde vs. antegrade) are:

- the age of the patient
- expected pathology (stone size and location, UPJ obstruction)
- presence of either an indwelling ureteral stent or an indwelling nephrostomy tube
- Coexisting musculoskeletal problems

RETROGRADE URETERAL ACCESS

Depending on the age and size of the patient, a number of pediatric URS procedures require some form of dilation of the ureteral orifice and possibly also the distal ureter. The advantages of controlled ureteral dilation (passive or active) prior to retrograde URS include:

- the wider distal ureter allows larger ureteroscopes to be used. This improves the visualization during the procedure and also provides for a larger selection of instruments that can be passed through the larger working channels
- a dilated ureteral orifice allows increased flow of irrigant around the ureteroscope, increasing intra-operative visibility

There are multiple techniques to achieve ureteral dilation. These include:

URETERAL STENT (PASSIVE DILATION)

This approach is used when the patient is pre-pubertal (to minimize the risk of injury to the intramural ureter and the theoretic risk of inducing reflux). The child undergoes initial ureteral stent placement via a cystoscope (stent size dependent on patient size 3.7–4.8 Fr). The patient is maintained on antibiotic prophylaxis while the stent is in place.

The patient is returned to the operating room after 3–14 days to undergo the definitive URS procedure using a 6–7.5 Fr flexible ureteroscope or a 4.5 Fr semirigid ureteroscope. With this staged approach, subsequent balloon dilation of the ureter for URS is rarely necessary.

URETERAL ACCESS SHEATH (APPLIED MEDICAL™) (SINGLE-STEP ACTIVE DILATION)

This technique is useful when multiple passages of the ureteroscope are anticipated. The sheath prevents significant trauma to the ureteral orifice and/or the intramural ureter during the procedure. Various sizes are available (10–12–14 Fr). The manufacturers' specification sheet (Applied Medical™, Rancho Santa Margarita, California, USA) should be consulted for the luminal diameter recommended for the caliber of the specific ureteroscope being used.

BALLOON DILATION (ACTIVE DILATION, POTENTIALLY MORE TRAUMATIC TO THE URETER)

This approach may be applied to the older pediatric patient, where VUR is of diminished clinical significance. A variety of balloon dilation catheters are available, ranging in length from 5 to 10 cm. Ureteral dilation to 12 Fr in the older child should accommodate almost all of the available ureteroscopes, including the rigid scopes. Prior to the inflation, the balloon should not be tested as it might cause fatigue of the balloon material and also makes advancing the balloon more difficult.[12]

The maximum volume and pressure of the balloon recommended by the manufacturer should never be exceeded as this could lead to ureteral perforation if the balloon were to rupture.

Once the ureteral orifice has been dilated, a guide wire is placed into the ureter to secure access and provide a route for passing the instruments. The Bentson guidewire is the most suitable for initial ureteral access in most instances, in cases where ureteral narrowing is expected (e.g., partial obstruction from a calculus or ureteral stenosis) use of a glide wire should be considered. Care should be taken to avoid iatrogenic perforation of the urothelium during the passage of the wire. When using a glide wire, it is essential to keep the hydrophilic coating moistened to ensure easy passage of the wire. The glide wires are available with either a straight or an angled tip. The angled tip appears to be more helpful in traversing obstructed ureteral segments, especially when used in conjunction with a torque control device. Once the obstructed segment is passed with the wire, the ureteral catheter is advanced into the renal pelvis and the glide wire is exchanged for either a Bentson or an Amplatz Super Stiff guide wire.[12]

ANTEGRADE URETERAL ACCESS

This approach may be considered in a child who already has a percutaneous nephrostomy tube in place. This technique is particularly useful in the very young patient who presents with an obstructed ureter. (I have used this technique successfully in two patients [<1 year of age] who had presented with complete ureteral obstruction resulting from impaction of large calculi [8 mm in one of the patients]) [Figures 1 a–d]. After discussing the risks of sepsis, etc. and obtaining informed consent, it is helpful to have the parents of these patients occlude drainage of the nephrostomy tube for 1–2-h intervals during the daytime for a few days prior to the treatment. This permits hydrodistension of the ureter proximal to the stone and makes antegrade passage of the ureteroscope less traumatic.

Once the ureter has been accessed (either antegrade or retrograde) and a safety wire is in place, a second guide wire (the working wire) is placed. Placement of the second

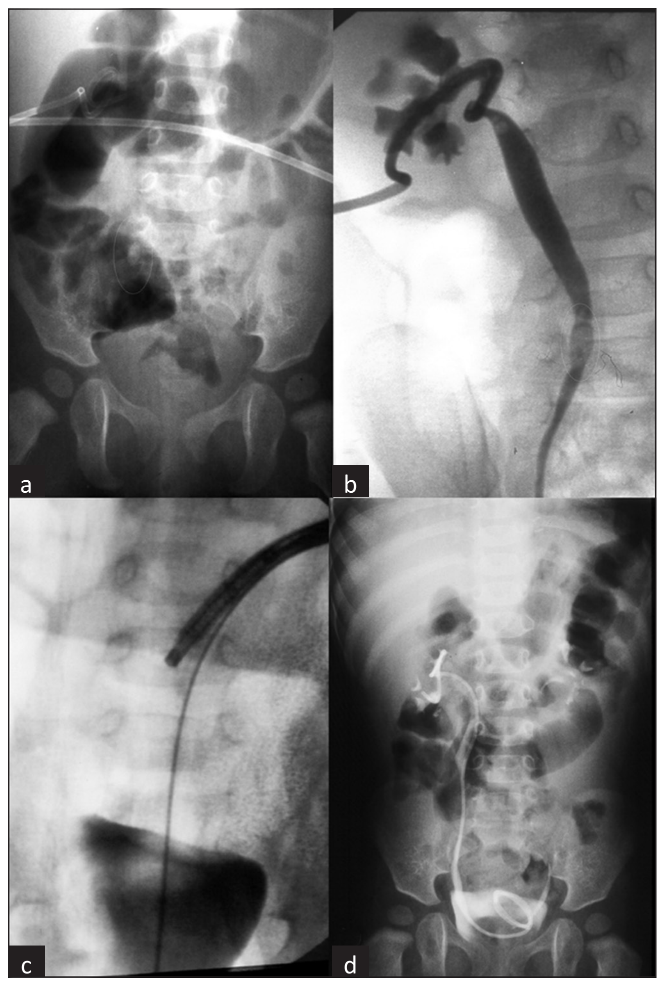

Figure 1: Management of an 11-month-old female infant who presented with urosepsis secondary to an obstructing right-sided mid-ureteral calculus (a) KUB demonstrating radiodense calculus on the right side (b) Antegrade nephrostogram (c) Intra-operative radiograph demonstrating antegrade ureteroscopy (d) Post-operative intravenous pyelogram demonstrating the indwelling ureteral stent

wire is facilitated by the use of a dual-lumen catheter. The ureteroscope is then passed over the working wire into the ureter under fluoroscopic guidance until the region of interest in the ureter is reached. Alternatively, the ureteroscope may be passed alongside the safety wire in a free-hand fashion with visual guidance. The working wire is then removed and the remainder of the procedure is performed under direct visualization, with the safety wire in place to maintain upper urinary tract access. While performing flexible URS in the older child, it is useful to leave the cystoscopic sheath in place in the bladder to facilitate the passage of the ureteroscope and emptying of the bladder (it is important to remember that when using the Amplatz Super Stiff guidewire, the flexible ureteroscope cannot be back-loaded onto this wire; attempts to do so might result in damage to the flexible ureteroscope).

Visualization during URS is improved by irrigating with saline (using a 10 cc LeVeen inflator with pressure gauge (this produces a pulsatile flow and requires manual irrigation, but exposes the ureteral wall to lower pressure) or a bag of injectable saline compressed in a pressure bag (this allows for a steady, automatic flow).

TREATMENT OF UROLITHIASIS

Once the ureter has been accessed and the stone has been visualized, the surgeon can treat the stone with one of a number of intracorporeal lithotriptors based on their training and preference (Table 3 discusses the various lithotriptors currently available to the pediatric urologist). The holmium:YAG laser is currently the lithotriptor of choice for most urologists.

In the older pediatric patient, basketing the stone is also an option and should be undertaken with extreme caution. We recommend using tipless wire baskets (i.e., Zerotip™ Nitinol stone retrieval basket) as they minimize the risk of dislodging and proximal migration of the stone.

TO STENT OR NOT TO STENT?

Once the URS procedure is completed, placement of a ureteral stent is to be considered. The rationale for stent placement has traditionally been a potential decrease in stricture formation and post-operative pain; however, it is a well-known fact that ureteral stents can actually be the cause of significant pain.[13] More recently, the whole issue of post-operative stenting has been called into question and there is enough data to suggest that it is no longer a standard requirement: the decision to stent depends on the following factors:

- The age of the patient
- Size of the ureter
- Extent of intra-operative manipulation of the distal ureter and ureteral orifice
- Reliability of the parents
- Most importantly, the judgment and experience of the urologist

The duration of stenting remains controversial and is based on the pioneering work performed by Davis.[14] If, however, a stent is placed, the stent should be left in place long enough that the local edema from the procedure can resolve (minimum 48–72 h). Because the strings on the ureteral stents have to be removed at the time of placement (to prevent the child from pulling the stent out prematurely), these patients require a second anesthetic to remove the stent. The cost of inserting a stent and the second procedure (to remove the stent) can add as much as $3,727.82 (INR 1,71,852.50) to the cost of the initial procedure based on US healthcare rates.[15] There have been reports of children tolerating the strings exiting their urethra and leaving the stents in place until removed by the surgeon at about 3–5 days post-operatively.[16]

SUMMARY

URS is safe and efficacious in the management of pediatric urolithiasis. URS should be considered an essential part of the armamentarium of any urologist involved in the care of children and is now considered the standard of care for the management of pediatric urolithiasis. A thorough knowledge of available equipment and the anatomical and physiological differences of pediatric patients will ensure a successful outcome with minimal morbidity to these patients.

REFERENCES

1. Young HH, RW McKay. Congenital valvular obstruction of the prostatic urethra. Surg Gynecol Obstet 1929;48:509.
2. Shepherd P, R. Thomas, EP. Harmon, Urolithiasis in children: Innovations in management. J Urol 1988;140:790-2.
3. Ritchey M, Patterson DE, Kelalis PP, Segura JW. A case of pediatric ureteroscopic lasertripsy. J Urol 1988;139:1272-4.
4. Minevich E, Defoor W, Reddy P, Nishinaka K, Wacksman J, Sheldon C, *et al*. Ureteroscopy is safe and effective in prepubertal children. J Urol 2005;174:276-9.
5. Minevich E, Defoor W, Reddy P, Nishinaka K, Wacksman J, Sheldon C, *et al*. Ureteroscopy is Safe and Effective in Prepubertal Children. J Endourol 2003;17:A212.
6. De Dominicis M, Matarazzo E, Capozza N, Collura G, Caione P. Retrograde ureteroscopy for distal ureteric stone removal in children. BJU Int 2005;95:1049-52.
7. Monga M, Best S, Venkatesh R, Ames C, Lee C, Kuskowski M, *et al*. Durability of flexible ureteroscopes: A randomized, prospective study. J Urol 2006;176:137-41.
8. Landwehr LP, M. Boguniewicz. Current perspectives on latex allergy. J Pediatr 1996;128:305-12.
9. Donnelly LF, DP. Frush. Fallout from recent articles on radiation dose and pediatric CT. Pediatr Radiol 2001;31:388.
10. Garvin TJ, RV. Clayman. Balloon dilation of the distal ureter to 24F: An effective method for ureteroscopic stone retrieval. J Urol 1991;146:742-5.

11. Thomas R, Ortenberg J, Lee BR, Harmon EP. Safety and efficacy of pediatric ureteroscopy for management of calculous disease. J Urol 1993;149:1082-4.
12. Eiley DM, McDougall EM, Smith AD. Techniques for stenting the normal and obstructed ureter. J Endourol 1997;11:419-29.
13. Pryor JL, MJ Langley, AD Jenkins. Comparison of symptom characteristics of indwelling ureteral catheters. J Urol 1991;145:719-22.
14. Davis DM, GH Strong, WM Drake. Intubated ureterotomy; experimental work and clinical results. J Urol 1948;59:851-62.
15. Netto NR Jr, Ikonomidis J, Zillo C. Routine ureteral stenting after ureteroscopy for ureteral lithiasis: Is it really necessary? J Urol 2001;166:1252-4.
16. Eberhart RC, Su SH, Nguyen KT, Zilberman M, Tang L, Nelson KD, *et al*. Bioresorbable polymeric stents: Current status and future promise. J Biomater Sci Polym Ed 2003;14:299-312.
17. Caione P, De Gennaro M, Capozza N, Zaccara A, Appetito C, Lais A, *et al*. Endoscopic manipulation of ureteral calculi in children by rigid operative ureterorenoscopy. J Urol 1990;144:484-5.
18. Scarpa RM, De Lisa A, Porru D, Canetto A, Usai E. Ureterolithotripsy in children. Urology 1995;46:859-62.
19. Shroff S, GM. Watson. Experience with ureteroscopy in children. Br J Urol 1995;75:395-400.
20. Smith DP, GR Jerkins, HN Noe. Urethroscopy in small neonates with posterior urethral valves and ureteroscopy in children with ureteral calculi. Urology 1996;47:908-10.
21. Kurzrock EA, Huffman JL, Hardy BE, Fugelso P. Endoscopic treatment of pediatric urolithiasis. J Pediatr Surg 1996;31:1413-6.
22. Minevich E, Rousseau MB, Wacksman J, Lewis AG, Sheldon CA. Pediatric ureteroscopy: Technique and preliminary results. J Pediatr Surg 1997;32:571-4.
23. Jayanthi VR, PM. Arnold, Koff SA. Strategies for managing upper tract calculi in young children. J Urol 1999;162:1234-7.
24. Reddy PP, Barrieras DJ, Bägli DJ, McLorie GA, Khoury AE, Merguerian PA. Initial experience with endoscopic holmium laser lithotripsy for pediatric urolithiasis. J Urol 1999;162:1714-6.
25. Wollin TA, Teichman JM, Rogenes VJ, Razvi HA, Denstedt JD, Grasso M. Holmium:YAG lithotripsy in children. J Urol 1999;162:1717-20.
26. Van Savage JG, Palanca LG, Andersen RD, Rao GS, Slaughenhoupt BL. Treatment of distal ureteral stones in children: Similarities to the american urological association guidelines in adults. J Urol 2000;164:1089-93.
27. Bassiri A, Ahmadnia H, Darabi MR, Yonessi M. Transureteral lithotripsy in pediatric practice. J Endourol 2002;16:257-60.
28. Schuster TG, Russell KY, Bloom DA, Koo HP, Faerber GJ. Ureteroscopy for the treatment of urolithiasis in children. J Urol 2002;167:1813.
29. Thomas JC, DeMarco RT, Donohoe JM, Adams MC, Brock JW 3rd, Pope JC 4th. Pediatric ureteroscopic stone management. J Urol 2005;174:1072-4.
30. Tan AH, Al-Omar M, Denstedt JD, Razvi H. Ureteroscopy for pediatric urolithiasis: An evolving first-line therapy. Urology 2005;65:153-6.
31. Herndon CD, Viamonte L, Joseph DB. Ureteroscopy in children: Is there a need for ureteral dilation and postoperative stenting? J Pediatr Urol 2006;2:290-3.
32. Lesani OA, Palmer JS. Retrograde proximal rigid ureteroscopy and pyeloscopy in prepubertal children: Safe and effective. J Urol 2006;176:1570-3.
33. Singh A, Shah G, Young J, Sheridan M, Haas G, Upadhyay J. Ureteral access sheath for the management of pediatric renal and ureteral stones: A single center experience. J Urol 2006;175:1080-2.
34. Smaldone MC, Cannon GM Jr, Wu HY, Bassett J, Polsky EG, Bellinger MF, *et al*. Is ureteroscopy first line treatment for pediatric stone disease? J Urol 2007;178:2128-31.
35. Cannon GM, Smaldone MC, Wu HY, Bassett JC, Bellinger MF, Docimo SG, *et al*. Ureteroscopic management of lower-pole stones in a pediatric population. J Endourol 2007;21:1179-82.
36. Corcoran A, Mally D, Smaldone M, Bellinger M, Schneck F, Docimo S, *et al*. Flexible ureteroscopy for proximal stones in pediatric patients: How complete access simplifies the surgical approach. J Endourol 2007;21:A84.
37. Koura AC, Ravish IR, Amarkhed S, Nerli RB, Reddy M. Ureteroscopic stone management in prepubertal children. Pediatr Surg Int 2007;23:1123-6.
38. Tanaka ST, Makari JH, Pope JC 4th, Adams MC, Brock JW 3rd, Thomas JC. Pediatric ureteroscopic management of intrarenal calculi. J Urol 2008;180:2150-3.
39. Dave S, Khoury AE, Braga L, Farhat WA. Single-institutional study on role of ureteroscopy and retrograde intrarenal surgery in treatment of pediatric renal calculi. Urology 2008;72:1018-21.
40. Kim SS, Kolon TF, Canter D, White M, Casale P. Pediatric flexible ureteroscopic lithotripsy: The children's hospital of Philadelphia experience. J Urol 2008;180:2616-9.

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