Chapter 16

Modern Upper Urinary Tract Endoscopy

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Additional information is available at the end of the chapter

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1. Introduction

Upper urinary tract endoscopy has come a long way from the first endoscopic examination performed in 1912 by Young and McKay. They used a 9.5 F rigid cystoscope in a patient with a very dilated ureter [1]. Current semi-rigid and flexible instruments are purposely designed to allow diagnostic and effective therapeutic interventions with minimal associated morbidity. The timeline of this evolution is perfectly described elsewhere [2].This chapter summarises the instrumentation available to the modern urologist, the basic principles behind their use and the major clinical outcomes now expected from their use.

2. Technology

This section will describe the endoscopes in modern use and the ancillary equipment we use for therapeutic indications. While some units still use a rigid ureteroscope these have been replaced in many units by semi-rigid and flexible ureteroscopes.

2.1. Endoscopes

2.1.1. Semi-rigid

The semi-rigid ureteroscope is the workhorse of endoscopic ureteric surgery. It was developed from the larger rigid ureteroscope primarily because of concerns about the inability of the rigid scope to access the upper ureter without causing significant damage to the urothelium. The "flexibility" and reduced size are primarily due to the introduction of fibre-optics.

The fibre-optic bundles (clad for image transmission, unclad for light transmission) are fixed at both ends which permits movement without loss of picture quality.

Modern scopes have either straight (Figure 1) or offset eyepiece. The only advantage of the offset eyepiece is that it allows the use of larger therapeutic instruments.The shaft is usually tapered so that the distal diameter (4.5 – 9 F) is less than the proximal (6.5-15F). The difference between proximal and distal diameter varies between manufacturers but is of the order of 2-4 F. The scope length is described as being "short" at approximately 30 cm or long at 40+ cm. Short scopes are useful for the lower ureter in males and lower and upper ureter in females. The long ureteroscope is best for visualisation and treatment in the upper ureter.Within the metallic sheath are the fibre-optic bundles and either one or two working channels. If two channels are being used, one tends to be larger to allow instrumentation and either continued of irrigation or a second working instrument.The distal end tends to be ovoid (figure 2). A variety of accessories are available to improve irrigation flow but the vast majority of procedures are done using gravity, either alone or using pressurised irrigation bags.

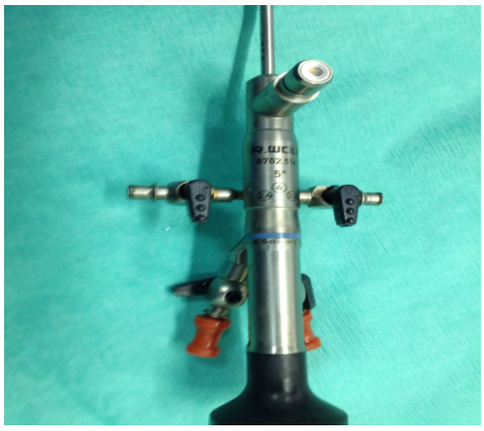

Figure 1. Headpiece of modern semi-rigid Ureteroscope. This model has a straight eyepiece with two working channels each with a red rubber seal. In this model both channels are equal in diameter.

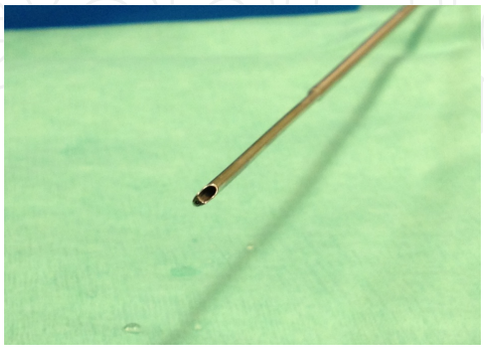

Figure 2. Distal tip of a semi-rigid ureteroscope showing the larger opening of the working channels (right side) compared to the optical opening. Note the stepped appearance as opposed to a more usually seen tapered tapered appearance. The lens is angled at 5 degrees to allow visualisation of the working instruments as they exit the channel.

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Semi-rigid ureteroscopes are very durable instruments. The biggest reason for failure is improper use or maintenance. Factors associated with failure are age, shaft design (tapered < stepped) length (long > short) and diameter (narrow > wider). While the instruments flexibility has increased its therapeutic potential, it also increases its susceptibility to breakage and deflections above 5cm are said to be particularly damaging to the instruments [3-4].

Figure 3. An Olympus flexible ureteroscope (single active deflection, one thumb handle) and Wolf semi-rigid ureteroscope.

2.1.2. Flexible ureteroscopy (figure 3)

2.1.2.1. Historical perspective

The first flexible ureteroscope was introduced through a ureterotomy at open surgery in 1960 [5]. The first trans-urethral instrument was used in 1962 to treat a stone in the lower ureter. This instrument and its immediate successor were diagnostic instruments which could not be manoeuvred. In addition they required forced diuresis to keep the ureter patent. A group from the University of Chicago pioneered the next major developments to incorporate a deflecting tip. This instrument still required insertion into the ureter through a rigid channel but was the first flexible ureteroscope to resemble a modern instrument [6]. The same group were the first to trial an actively deflecting flexible ureteroscope and introduced secondary passive deflection to produce the modern ureteroscope [7].

2.1.2.2. Modern design

The basic design of the instrument is similar to the semi-rigid instrument.Each uses non-coherently arranged light bundles for light transmission (flexi uses 1-2 only) and coherently arranged bundles for image transmission (flexi uses one). Likewise there is a working channel (one) which is usually 3.2 F diameter. In the flexible scope this is cylindrical and situated slightly off-center. This is because of the fibre-optics for image transmission.The degree of eccentricity of the working channel is greater with increasing diameter and results in a disproportionate larger loss of deflection when using instruments. A further loss of deflection ability comes from using “stiffer” instruments.The flexible ureteroscope is also hard wearing but rather than drawing its strength from steel column strength comes from composite poly-

meric materials. They also come in variable lengths (54 – 70 cm) and are tapered with a distal end of 4.9 – 11 F (most 5.3 – 8.7) and a proximal diameter of 5.8 – 11F(most 7.7-9.9).

2.1.2.3. Differences between semi-rigid and flexible ureteroscopes

The essential difference between the two types of ureteroscope are in terms of optics and ability to deflect. The fibre-optic bundles are smaller in the flexible scope. This usually does not adversely impact on light intensity because of the higher refractive index of the bundles. The angle of view is altered by fitting the distal bundles with an angled lens. Usually this is up to 10° and allows visualisation of instruments as they exit the working channel. The depth of view is less in the flexible scope due to fibre-optic technology, this is compensated for by magnification and focusing. This is a feature common for all flexible endoscopy.

The major difference between the two types of ureteroscope is in the degree of movement available with the flexible instrument. The initial range of deflection was up to 170°. This was based on the measurement of the maximum uretero-infundibular angle [8]. The most modern ureteroscopes can deflect to 270° both sides.

Deflection is sub-divided into active and passive deflection.Active deflection is controlled by a lever mechanism just behind the eyepiece. The basic principle behind this is that moving wires which pass through the scopes cladding and which are fixed to the distal tip causes the scope to bend. Where one lever is present this is called primary active deflection. The most modern scopes have a second active deflection mechanism (figure 4). Passive deflection is facilitated by a "softer" segment of the ureteroscope which on contact with the curves of the intra-renal collecting system allows the scope to be deflected. This allows inspection of and treatment in all parts of the collecting system.

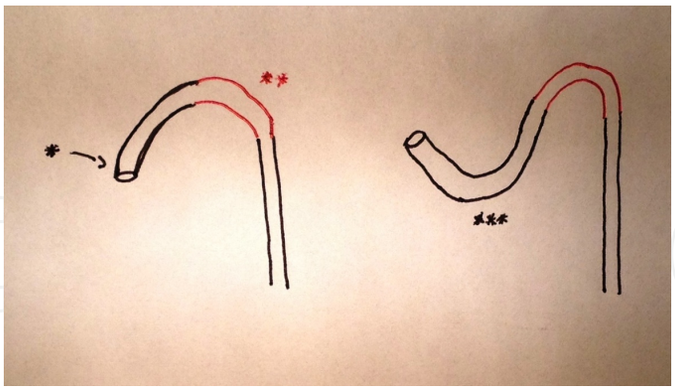

Figure 4. Cartoon depicting deflection in a flexible ureteroscope. The softer segment (**) is represented in red and is the point at which the flexible ureteroscope "bends" on contact with the urothelium. The single * represents the point of primary active deflection and the double ** represents the point of secondary active deflection.

Not surprisingly the flexible ureteroscope does not have the same longevity as the semi-rigid ureteroscope and the cost of repair is about twice that of a semi-rigid ureteroscope. The risk factors for damage are increasing length and decreasing diameter of flexible ureteroscope, instrument or laser damage to the working channel or overzealous deflection within

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the collecting system especially with an instrument in situ[4]. Pietrow et al have looked at factors to increase the lifespan of flexible instruments. The instrument should be stored with the headpiece upright and the tip dependent. At no time should the shaft be bent, as to do so risks damaging the light bundles. This damage is evident as black dots within the image. When inserting instruments it is best to ensure that the tip is straight and a laser should not be activated until the tip of the fibre is about two mm from the telescope. As repeated insertion can be damaging it is thought that access sheaths can prevent damage. The use of softer wires (eg Nitinol) and smaller calibre laser fibres can also help [9].

2.2. Ancillary technology

These are the instruments and technology which turn the instrument from a diagnostic tool into a potent therapeutic modality.

2.2.1. Tissue / stone destruction

There are four techniques for stone destruction in use in Urology. Of these two (laser and EHL) are most widely used in ureteric and intra-renal endoscopy.Electro-Hydrolic Lithotripsy (EHL) uses the cavitation bubble produced by an electrically induced spark to destroy calculi. This is achieved by the expansion of the bubble resulting in a shock wave, followed by its collapse and rebound off any surface with which it comes into contact. Using a 5F probe up to 90% of ureteral calculi can be successfully treated. The advantage of this technology is that it is relatively inexpensive with low running costs. The disadvantage is that, because of the uncontrollable nature of the shock wave, fragments are propelled forward. This is also the explanation for the ureteric perforation rates of up to 8.5% [10].For best results the probe should be held at a minimum distance of 1 mm from the stone and 1-2 mm from the ureteroscope and urothelium.

Ultrasound, pneumatic and EHL sources are useful only for treating calculi. Hence for treatment of upper tract lesions or haemostasis for biopsy other technologies are required. Contact diathermy probes are available but are limited by size to treating ureteric and renal pelvic lesions. Their use with a flexible ureterorenoscope limits deflection.

The primary energy method used in endourological management of both stones and small volume upper tract TCC is LASER. While many laser types have been used the main laser used is the Holmium: YAG laser (figure 5). The primary reason for this is that it is the only laser capable of destroying any stone type. The Holmium is a solid state pulsed laser with a wavelength of 2100 nm and delivers the enrgy through quartz fibres. The fibres range in size from 200 – 1000 μm. In our unit we use a 270 and 365 μm fibre both of which can be used through a semi-rigid and flexible ureteroscope. Most lasers use an acoustic shock wave (similar to EHL) generated by vaporising the fluid in front of the fibre creating a gas bubble.The Holmium laser does produce vaporisation but its primary effect is photo-thermal thus effectively evaporating the stone or tissue [11]. This produces tiny fragments of approximately the same size as the fibre. This is in contra-distinction to other energy forms which produce uneven larger fragments. However retro-pulsion of fragments can occur being seen most

with larger fibres. Like EHL, the holmium laser can damage urothelium and perforate the ureter. However this requires direct contact with the urothelium as because of its high absorption in water the laser energy penetrates no more than 1 mm into hydrated tissue. It has been estimated that this contact time is of the order of two seconds [12].

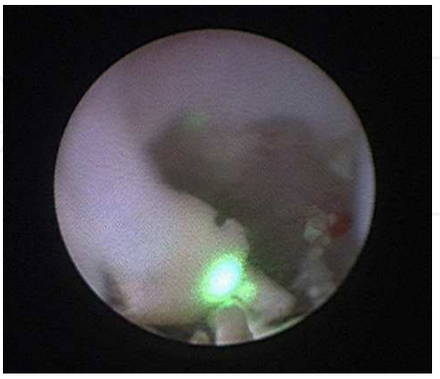

Figure 5. A holmium laser in use on an intra-renal stone at semi-rigid ureteroscopy.

2.2.2. Anti-migration devices

As indicated above one of the biggest problems withtreating stones in the ureter is retropulsion. There have been a number of approaches to reducing this migration. The most common approach is to place a device beyond the stone in a closed manner. Once past the stone the device is deployed to form a barrier to retrograde stone passage.The most used examples of this are the Stone cone © (Boston Scientific) (figure 6) and the N-Trap (Cook Medical). The Stone Cone is a Nitinol based wire with a length which is softer and forms a conical shaped when deployed. It is straightened by passing it over a wire and assumes its natural shape once the wire is removed. The N-Trap when deployed from its access sheath forms a basket. Laser lithotripsy is then performed and any fragments which migrate upwards do so into the Cone/Basket. At the end of the lithotripsy procedure, the Cone/Basket is gently removed under vision with the ureteroscope. Both devices are designed to release a stone fragment when a threshold level of pressure is reached. This prevents larger fragments impacting in the ureter at attempted removal.

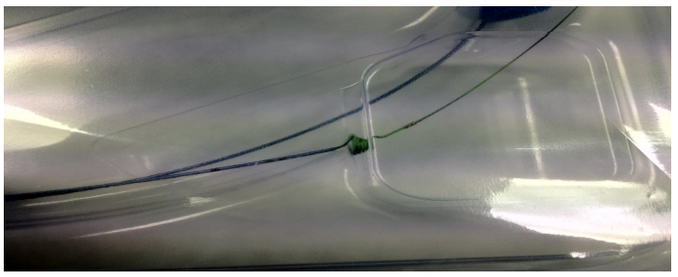

Figure 6. The Stone Cone (Boston Scientific) in its "cone" shape prior to use.

A newer approach is to inject a liquid polymer above the stone which on exposure to body temperature solidifies. This forms a seal or plug which prevents migration. Once the stone is destroyed cold saline irrigation is used which liquefies the gel. The polymers construction is such that any residual gel is degraded and gone from the ureter by two hours. The only commercially available model is the Backstop from Boston Scientific.

2.2.3. Baskets and graspers

These come in multiple shapes and sizes with the primary aim of grasping or trapping the stone fragments. This allows physical removal of the fragments. Graspers tend to have three prongs which facilitates extraction of "larger" fragments. They tend to have a co-axial design with inner and outer sheaths. Retrieval is facilitated by advancing the inner sheath. Baskets are designed to trap multiple small fragments within their Nitinol wires. There are various designs with varying features aimed at improving the stone free rate post lithotripsy. Tipless designs are said to reduce the risk of urothelial perforation. A recent trend is the basket in which laser lithotripsy can be performed with the laser fibre being introduced through the hollow shaft (eg Cook Flat wire stone extractor).

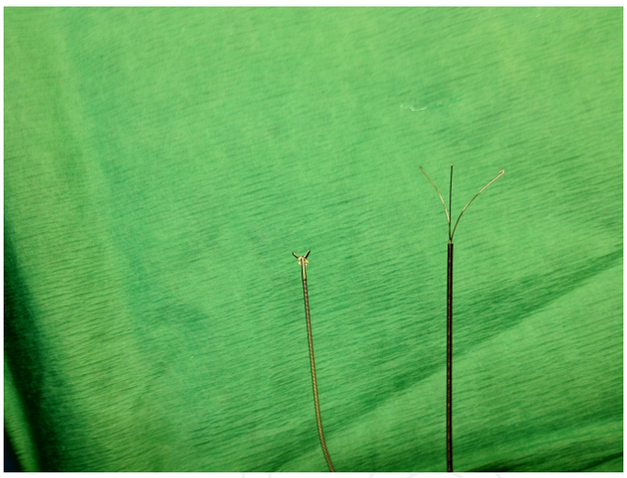

Figure 7. A re-usable ureteroscopic biopsy forceps (left) and a tri-radiate grasper (Captura, Cook medical)

2.2.4. Biopsy forceps

These instruments are a standard part of the endourologists arsenal. They are used for foreign body removal in the case of a migrated JJ stent. Also they are useful for biopsy of intraureteric lesions for histological evaluation. However because of size constraints resultant from the dimensions of the ureteroscope, they are very small and the biopsy sample attained is often too small for analysis. A solution to this was developed by Cook. They backloaded a larger biopsy forceps (Bigopty) through the ureteroscope and then connected it to the biopsy handle. The biopsy forceps thus enters the ureter before the ureteroscope and hence can be of greater size (figure 8).

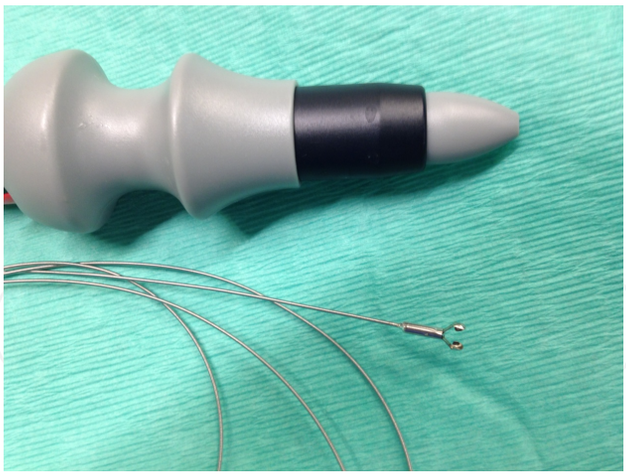

Figure 8. Bigopty (Cook Medical), a backloaded ureteric biopsy forceps,capable of taking large biopsy samples.

3. Ureteroscopy technique

All uretersocopy is preceded by a careful cystoscopy. A negative MSU or treatment with culture appropriate antibiotics is mandatatory. Active infection is the only absolute contra-indication to ureteroscopy. Relative contra-indications are ongoing anti-coagulation therapy or bleeding diatheses. Appropriate antibiotic prophylaxis is given at induction of anaesthesia. This has been shown to reduce infection rates from 13 to 2% [13].Ureteroscopy is usually under a general / spinal anaesthetic with the patient in the lithotomy position but can also be performed in the flank or prone positions.Some authors suggest that the ipsilateral leg be straightened to facilitate ureteral entry.A careful cystoscopy prevents bleeding from the bladder neck which can impair vision and identifies situations where ureteral access is more difficult such as the man with a median lobe or high bladder neck. The primary aim of the cystoscopy is to insert a 0.035 to 0.038 inches guidewire (“floppy” end first) into the relevant ureteric orifice which facilitates the safe introduction of the semi-rigid ureteroscope. This is placed into the renal pelvis under fluoroscopy so that the floppy end is seen to be coiled. This wire is typically called the “safety” wire. Should this prove difficult, the bladder should be emptied and a further attempt made. If it still proves difficult a ureteric catheter can be used to straighten the intra-mural ureter (figure 9). This usually allows the wire to pass. The bladder is emptied on completion to avoid distortion of the ureteric orifice and minimise kinking of the intra-mural ureter.

3.1. Semi-rigid ureteroscopy (AUA and EAU guidelines, ref 14-15)

The initial step is introducing the ureteroscope into the ureteric orifice. The tip of the scope can be passed under a ”safety” guidewire to facilitate entry. If this does not permit entry then the scope should be rotated. Should this fail a second wire can be introduced and the tip of the scope passed between the two wires. This is called “rail-roading” (figure 10). If this

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does not work then the next step is dilatation of the ureteric orifice and should that fail then a JJ stent is placed. This results in dilation by loss of peristalsis. Interval ureteroscopy can then be performed after approximately two weeks.

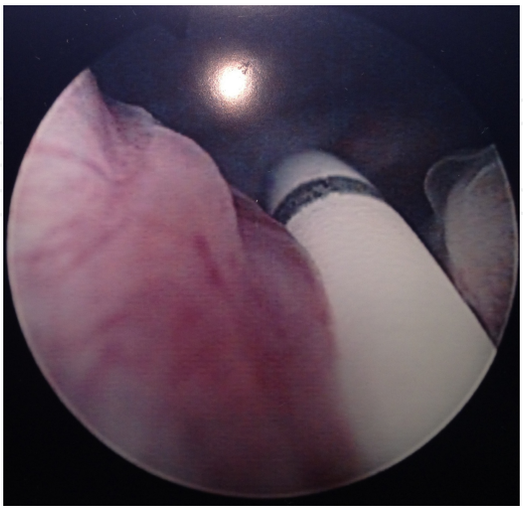

Figure 9. Use of a ureteric catheter (white tube) to facilitate entry into the left ureteric orifice in a man with a median lobe of prostate and a high bladder neck.

A longer ureteroscope is needed in males due to the combination of the longer urethra, the relatively immobile prostatic urethra and the better development of the Psoas muscle. The latter factor can make it difficult to negotiate the ureteroscope beyond the iliac vessels. A second wire can sometimes help straighten a tortuous ureter. However, excessive force should be avoided because of the risk to the ureter (mucosal damage, perforation) and to the ureteroscope because of shear forces.

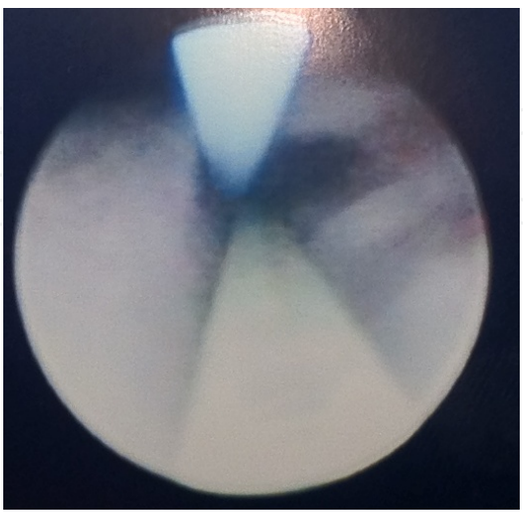

Figure 10. View from a ureteroscope as it is being inserted into the left ureteric orifice between two guidewires (rail-roading)

3.2. Flexible ureteroscopy (AUA and EAU guidelines ref 14-15)

Most flexible ureteroscopy is preceded by a semi-rigid examination of the ureter. This amongst other things dilates the ureteric orifice as well as allowing placement of a second guidewire. This second wire usually straightens out the ureter. There are two schools of thought on flexible ureteroscopic technique. One will introduce the flexible scope into the urethra and either beside or loaded along the guidewire into the ureteric orifice. The other will use a ureteric access sheath to allow repeated easy access to the ureter. A ureteric sheath (figure) is placed over a stiff guidewire under screening to the lower or mid ureter depending on the level at which the operator needs to work. The flexible ureteroscope is then placed through the sheath directly into the ureter. Where repeated insertions/removals are necessary, the access sheath reduces instrumentation time. The advantage of using the sheath is that it may reduce the intra-renal pressure during prolonged stone procedures hence minimising the risk of nephron loss.Once in the collecting system, the flexible ureteroscope can be manoeuvred to directly visualise all calyces. This is by a combination of torquing (twisting) the scope itself and active and passive deflection. Visualisation of the calyces is helped by retrograde contrast injection and radiological screening, thus outlining the whole system.

3.3. Complications of ureteroscopy (specific to ureteroscopy)

Ureteroscopy is performed in the lithotomy position. This position increases the risk of DVT and for this reason most endourologists use compression boots. The risk is small with modern series reporting a risk of 0.2%. The other risk of positioning is damage to nerves such as the common peroneal through inadequate padding. Thankfully the risk is very small and the damage is usually temporary.

Ureteric complications range in severity from bleeding to complete avulsion. Bleeding is usually self limiting and occurs following instrumentation. Its reported in 0-2.1 % of series and usually does not prevent procedure completion. The majority will settle with an indwelling JJ stent/ ureteric catheter for at most two weeks. More significant ureteric damage results in either a tear or perforation. A tear is defined as a breach in the urothelium. It is best to move any stone away fro the tear into dilated ureter to prevent further damage. Again they usually respond to a short period of stenting. Ureteric perforation occurs in one to five percent of modern studies. The rate is decreasing due to increasing experience and (more significantly) smaller calibre instruments.Stenting is the mainstay of management and it is in this situation that the safety wire really helps. The stent can be placed over the safety wire which has been pre-positioned into the renal pelvis. If the patient does not settle or develops an infected urinoma then a percutaneous nephrostomy may have to be placed.It is exceptional to require open repair of a perforation.

Ureteric intussusception (urothelium only, muscle in place) and avulsion are the most severe forms of ureteric injury. Both are due to overly aggressive attempts to remove stone fragments or to forcing a ureteroscope through a narrowed ureteric segment. The golden rule is to stop and re-evaluate. In the case of a ureter which will not accept a scope then the narrowed are can be dilated under radiological screening or a JJ stent can be left for a period

of four weeks. The stent causes ureteric dilation and ureteroscopy can usually be completed at the time of stent removal. In the situation where a stone laden basket will not negotiate a narrowed area then it should be gently moved back up to dilated ureter and opened. This will release some fragments and permit a further attempt at removal. If this fails it means that the fragments are too large and further laser lithotripsy is warranted. If the basket will not open then it can be disassembled and laser lithotripsy performed to the fragments within the basket.If either avulsion or intussusception is suspected then an immediate retrograde examination is performed. If the renal collecting system is not outlined with contrast then the diagnosis is confirmed. Drainage of the collecting system is mandatatory and this is usually with a percutaneous nephrostomy. Open surgery is required and the technique used will depend on the site and extent of injury.

4. Upper tract stones

4.1. Introduction

Between 1200 and 1400 per 100,000 people will develop urinary stones each year with a male:female ratio of 3:1.The majority of stones are composed of calcium oxalate, often mixed with calcium phosphate, in both adults and children. The acute presentation is usually unmistakable with the classical history of loin to groin colicky pain. Evaluation with non-contrast CT is advisable for diagnosis. The immediate management usually involves analgesia and treatment of any infection present, and then determining definitive management [14]. Stones smaller than 5 mm will generally pass, but larger stones often require urological intervention [16]. For the purpose of this chapter, the management of upper urinary tract stones will be explored and outlined with the emphasis being on endourological management.

4.2. Management

The options available for the management of upper urinary tract stones include observation, Extra-Corporeal Shock wave Lithotripsy (ESWL), Ureteroscopy, Percutaneous Nephro-lithotomy (PCNL),laparoscopy and rarely open surgical removal. The appropriate modality for each individual patient will depend on the interaction between stone (size, location, appearance of the stone on imaging, composition),anatomical abnormalities, the presence of infection and concomitant co-morbidities which may affect the decision regarding appropriate anaesthetic time.There also is an increasing trend toward intervention because of technological improvements and a growing dissatisfaction with the overall success rates with extracorporeal shock wave lithotripsy [17].

Most stones less than 5mm in size will pass spontaneously.European Association of Urology guidelines state that active stone removal is recommended for renal stones >6-7mm in size [14]. However, those of less than 6mm in size, if symptomatic, can be considered for treatment [14-15].

4.2.1. Non invasive treatment of upper tract stones

ESWL is entirely non invasive, and it uses super sonic waves to fragment stones into small pieces that can be easily passed. Shortly after its introduction in 1983, it became widely accepted as the first line treatment modality for the majority of stones and rapidly replaced invasive surgical options. ESWL is effective for most renal stones less than 2 cm in size and ureteric stones less than 1 cm in size [18].In patients with normal anatomy, and with non lower pole renal stones < 20mm in size, ESWL is recommended as first line treatment. Lower pole stones have a higher failure rate with ESWL and so other treatment modalities should be sought (see below). In one study which compared stone free rates of ureteral stones of variable sizes and locations which were treated by ureteroscopy or extra-corporeal shock wave lithotripsy, ESWL was associated with a success rate of 64% (up to two treatments), as compared to 96% for ureteroscopy in a single treatment [17].

It is important to highlight that certain stone composition such as cystine or phosphate stones may be resistant to fragmentation.There are also multiple other contra indications to the use of ESWL which include pregnancy, bleeding diatheses, severe obesity, anatomical obstruction distal to the stone.

4.2.2. Invasive treatment of upper tract stones

Larger stones, particularly those composed of cystine or struvite, can be approached via establishing percutaneous access to the collecting system through a small flank incision. This would allow direct visualization and intra-corporeal lithotripsy for stone disruption, and removal of fragments known collectively as Percutaneous nephrolithotomy (PCNL).

PCNL has high success rates of around 90% however there are risks onvolved, and major intra-operative or post operative complication rates are often reported as 0.03% to 10% [19]. However, ureteroscopy is fast becoming the main form of treatment for upper urinary tract stone management and this is what will be discussed for the purpose of this chapter.

4.2.3. Selecting the treatment for a patient with stone management

Intra-renal calculi

Different stone sizes respond better to different therapies and success rates are variable for the size of stone. The European Urological Association recommends the following management plan for kidney stones in the renal pelvis or upper/middle calyx, categorised according to size:

Flexible ureteroscopy is used less as a first line treatment for stones > 1.5cm in size. However with ongoing improvements in newer generation flexible ureteroscopes, there is an increasing trend toward ureteroscopy and laser lithotripsy for intr-renal calculi of all sizes and compositions. In the available literature, there are very few reported studies on the use of semi rigid ureteroscopy to treat renal stones. A prospective analysis performed by Bryniarski and co-workers assessed the safety of PNCL and retrograde intrarenal surgery use semi rigid ureteroscopy for the management of renal stones of >2cm in size. Although stone free

rates were superior in the PCNL group, the semi rigid ureteroscopy provides advantages for operating times, haemoglobin loss, post-operative visual analogue scoring by patients and reduced hospital stay [20]. The situation is slightly more complex in lower pole stones as the following table shows.

Stones <1cm in size	Stones 1-2cm in size	Stones >2cm in size
ESWL	ESWL or endourology	Endourology (PCNL / flexible ureteroscopy)
Flexible ureteroscopy		ESWL
PCNL		Laparoscopy

Table 1. European Association of Urology (EAU) recommendations for the treatment of Renal stones.

Treatment for renal calculi in the inferior calyx is also very dependent on size:

Stones <1cm in size	Stones 1-2cm in size	Stones >2cm in size
ESWL	Favourable factors for ESWL?	Endourology (PCNL or ureteroscopy)
Flexible ureteroscopy	No -> Endourology	
PCNL	Yes -> ESWL or endourology	

Table 2. EAU recommendations for the treatment of Lower pole stones.

Ureteric Calculi

The management of ureteric calculi is also dependent on the size of the stone involved. The table below outlines the European Urological Association guidelines for Stone management dependent on size of stone:

Location	Stone size	1st choice	2nd choice
Proximal ureter	<10mm	ESWL	Ureteroscopy
	>10mm	Ureteroscopy (retrograde or antegrade) or ESWL	Ureteroscopy (retrograde or antegrade) or ESWL
Distal ureter	<10mm	Ureteroscopy or ESWL	Ureteroscopy or ESWL
	>10mm	Ureteroscopy	ESWL

Table 3. EAU recommendations for the treatment of Ureteric stones

The outcomes of ureteroscopy

The European Association of Urology and the American Urological Association guidelines Panel have published stone free rates for different treatment modalities within their nephrolithiasis guidelines.In a cohort comparison group (early 1980s vs 1992) the success of ure-

teroscopic procedures rose from 86% to 96%. In addition, they observed an overall decrease in complications (20% to 12%) in ureteroscopy and 6.6% to 1.5% in ureteroscopic laser lithotripsy [21]. Partly, this was thought to be due to greater surgeon experience and that this is significantly correlated to higher success and lower complication rates in ureteroscopic laser lithotripsy with holmium laser [21].

Renal Calculi

The success rates (stone free or insignificant fragments) reported with PCNL are greater than 90% for renal stones >2cm. However, major complications during or after PCNL occur at reported rates of 0.03 % to 10% [22]. The success rates of retrograde intra-renal surgery have been reported as 75-95% for intra-renal stones >2cm after the first or second treatment, whereas the major or minor complications vary from 1.5 % to 12% [23].This is less frequent than rates in PCNL procedures. Major complications in ureteroscopy such as ureteric perforation or avulsion are extremely rare.

Ureteric Calculi

One study of a two year experience, highlighted that the success rates following ESWL were heavily influenced by stone size.The overall stone free success rate was 74.7% with one session. However, as the size of the stone increased, the success rate reduced. For stones <1cm the success ratewas 83.6%and when the stone size > 1cm the success rate reduced to 42.1%. The stone free rates also varied according to the site of the stone - 72.4% (proximal), 70% (mid ureter), and 82% (distal) after a single session [14-15].

In ureteroscopy, an overall stone –free rate of 87.8% was obtained irrespective of the size of the stone (88.9% for <1cm and 86.6% for >1cm). The success rates did slightly vary in relation to the stone site. The stone-free rates were 75% (proximal), 94.6% (mid ureter) and 84.6% (distal) [24].

The American Urological Association recent 2012 guidelines have published stone free rates for Shock Wave lithotripsy and ureteroscopy for the treatment of ureteric calculi and these are outlined in the tables below:

Proximal ureter:

Treatment	Overall	Stone size < 10mm	Stone size >10mm
ESWL	82%	90%	68%
Ureteroscopy overall	81%	80%	79%
Flexible ureteroscopy	89%	84%	

Table 4. Proximal Ureter; stone clearance comparison between Ureteroscopy and ESWL.

Mid Ureter:

The reduced success for stone free rates using ESWL in the mid ureter is likely explained by the anatomical changes at this site. The mid-ureter is closely related to the transverse proc-

esses of the lumbar verterbrae and focus of the lithotripsy beam is more difficult due to the anatomical relationships to the spine.

Treatment	Overall	Stone size < 10mm	Stone size >10mm
ESWL	73%	84%	76%
Ureteroscopy overall	86%	91%	78%
Flexible ureteroscopy	88%	Not documented	Not documented

Table 5. Mid Ureter; stone clearance comparison between Ureteroscopy and ESWL.

The reduced success for stone free rates using ESWL in the mid ureter is likely explained by the anatomical changes at this site. The mid-ureter is closely related to the transverse processes of the lumbar verterbrae and focus of the lithotripsy beam is more difficult due to the anatomical relationships to the spine.

Distal ureter:

Treatment	Overall	Stone size < 10mm	Stone size >10mm
ESWL	74%	86%	74%
Ureteroscopy overall	94%	97%	93%
Rigid ureteroscopy	94%	98%	94%

Table 6. Distal Ureter; stone clearance comparison between Ureteroscopy and ESWL.

The use of holmium laser lithotripsy via ureteroscopy is safe and effective in urinary stone management, particularly for larger calculi. It is associated with success rates of more than 90% and with complication rates as low as 10%.

In a study which described 300 procedures of ureteric stone lithotripsy with holmium laser, there was an overall complication rate of 10%. Their overall success rates were 90% and after the first episode, 86% were stone free [21]. In another series of 598 patients, the overall complication rate was 4%, with an overall the success rate of 97% and 94% after the first episode [25].

5. Upper tract Transitional Cell Carcinoma (TCC) / malignancy

Upper tract TCC accounts for approximately 10% of all renal tumors and 5% of all urothelial tumors. It is found to be more common in Caucasian, occurs more often in the sixth to seventh decade of life [26]. Worryingly there is evidence to suggest that the incidence of upper tract TCC is increasing [27]. The presentation is usually with haematuria and approximately 30% will have “ureteric colic” secondary to blood clot [28]. They occur more commonly in people with a history of bladder cancer.

CT Urography is the standard diagnostic tool. However non-visualisation of lesions has been reported in 20% of renal pelvis and 40% of ureteric tumors. Ureteroscopy (semi-rigid or flexible) has been used to improve this accuracy as well as provide histological confirmation (figure 11). Williams et al have shown that ureteroscopic biopsy accurately predicts final histology at Nephro-ureterectomy in 75% of cases and further increases accuracy when combined with exfoliative cytology (brushing the lesion with a brush passed endoscopically) [29]. Ureteroscopic technique is as outlined before with the exception of use of a safety wire. While a wire is used, it should be placed in the ureter under direct ureteroscopic vision. This is because wire related urothelial trauma can mimic TCC and such trauma does make cytological analysis more difficult.

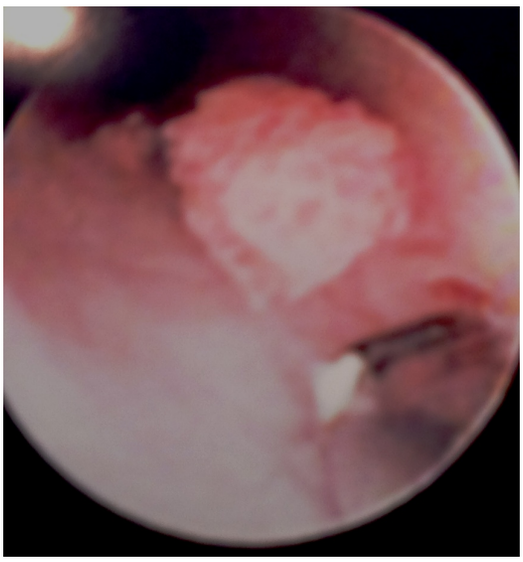

Figure 11. Bigopty ®(Cook Medical) forceps removing a superficial TCC from the ureter.

Radical nephroureterectomy with an ipsi-lateral bladder cuff is still the gold standard treatment for upper tract TCC. Endourological management was initially introduced for those in whom such radical procedure was not possible or who would have required dialysis post operatively. However, the indications for endourological management increased with increased experience [30]. Now endourological management can be considered as potentially curative for all bar those with high-grade or bulky lesions [31].

Because the indications for endoscopic management of upper tract TCC have expanded so rapidly it is difficult to evaluate its efficacy. Potential markers of success are the subsequent recurrence rate and the need for Nephro-ureterectomy.For tumors of the renal pelvis the recurrence rate is quite stable at 40%. This is not that dissimilar to bladder recurrences following endoscopic treatment of bladder TCC.However when looking at recurrences following treatment of ureteric tumors the rates have increased from 14 up to 25% with a corresponding rise in rates of nephro-ureterectomy from 4 up to 14%. It is unclear whether this reflects poor technique or the increasing expansion in use of ureteoscopy for upper tract TCC. As alluded to above the best tumors are those of low grade, solitary and small with a papillary

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appearance with negative cytology [32]. From the point of view of laser choice the Holmium is best for resection and Neodymium YAG is best for fulgaration.

6. Ureteric stricture / Pelvi-Ureteric Junction (PUJ) obstruction

PUJ obstruction is a functional blockage to antegrade flow of urine to the bladder from the upper tract due to a narrowing at the PUJ. Its classically treated by an open (or laterally laparoscopic) procedure by the name of Pyeloplasty. Retrograde endopyelotomy is a minimally invasive option.This is performed using a large calibre rigid ureterorenoresectoscope or using a Holmium laser. The laser procedure is more common and usually linked with subsequent balloon dilatation of the incised area. The incision is made laterally at the PUJ to minimise vascular injury. The incision is deepened until peri-ureteric fat is seen. Balloon dilatation up to 24 F is then performed and a special stent inserted (Tapered with greater diameter at the top end) for six weeks. Longterm success rates of up to 77% have been reported. Failure usually requires either open or laparoscopic pyeloplasty. A split function of less than 20% and redundant renal pelvis are factors predictive of failure.

Ureteric strictures can also be treated with laser incision. For distal strictures the success rates are of the order of 75% with an average follow-up of 3 years. Failures tend to occur early [33]. Similar results are reported for mid-ureteric and proximal ureteric strictures. The technique for ureteroscopic surgery is again incision to peri-ureteric fat but also includes incision into normal tissue either side of the stricture.

An alternative form of endo-urological stricture management is to use a combined balloon dilator and Monopolar electrode. Identification of the stricture is radiological as once the balloon is inflated with contrast, the stricture will be identified as an indentation on the balloon ie “waisting”. As the procedure is not visualised an adequate incision is identified as contrast extravasation.

7. The future

There are now production models of video ureterorenoscopes. Their advantage is that they are smaller, more manoeuvrable with a better picture and fluid flow rate. These instruments use distal chip technology where the incoming light energy impacts on a digital chip. This energy transfer results in a charge which is transmitted along a single fibre to a processor which converts it into a usuable image.The better visual image is primarily due to less transmission loss. Energy (light) loss in fibreoptic ureteroscopes is multi-factorial but involves cladding damage, damage to the fibre-optic bundles, light lead / connection damage and camera head. It is primarily in the treatment of upper tract TCC where the improved imaging will be of most use. The increased magnification and resolution of the images together with technology such as Narrow Band Imaging should expand the place of ureteroscopy in the management of low grade upper tract TCC.

8. Conclusion

The use of endo-urological techniques in day to day urological practice is increasing. This is fuelled by many factors but amongst them is better technology, a greater number of trained individuals and a desire to improve patient experience while maintaining outcomes. The future will be even better as better image definition becomes more readily available as video-ureteroscopes become more durable.

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