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MINI REVIEW

Complications Due to Surgical Treatment of Ureteral Calculi

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Ureteral calculi usually induce severe colic pain, hematuria, hydronephrosis, infection and renal function loss, which warrant aggressive surgical management. The incidence of complication seems to decrease with the use of advanced equipment and machines in modern therapy. However, severe complication is still not unusual in our daily practice even as extracorporeal shock wave lithotripsy and endoscopic ureteral lithotripsy have become the most common urologic surgeries. It is important to be familiar with the surgical skills in the management of ureteral calculi as well as in dealing with complications that follow. In this short review, we discuss the complications with respect to the different mode of therapy and the different locations of the ureter, as well as the prevention and management of complications. Special conditions such as ureteral calculi in pregnancy, pediatric ureteral stones, outpatient ureteroscopy surgery, ureteral stents, ureteral dilatation and urinary leakage will also be discussed.

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There are 2 CME questions based on this article

1. Introduction

Primary ureteral calculi is not the only problem in the ureter that require surgical management. At present, most renal calculi are managed with extracorporeal shock wave lithotripsy (ESWL), which means that more stone fragments of different size pass through the ureter. Urologists have more opportunity to perform surgery for ureteral calculi. Unfortunately, numerous complications can occur during the different procedures, mostly during ureteroscopy with or without stone extraction. Even the most expert urologist may come across some unexpected iatrogenic injuries. Some severe injuries even lead to irreversible damage to the ureter and kidney. With improvements in ureteroscopy and intracorporeal lithotripsy, the success rate has increased from 50% to 97%.[1–3] The overall complication rate has decreased to 12–15%, with a major complication rate of 0.8–1.5%.[3–7] The incidence of complications is variable and associated with operative time, location of calculi, type of ureteroscope, experience of the surgeon, year of study, and inclusion criteria.[8,9] Although some therapeutic guidelines for calculi treatment have some suggestions for different sizes and locations of ureteral calculi,[10,11] the priority of treatment should be reexamined because of the higher success rate and lower complication rate of ESWL and ureteroscopic lithotripsy (URSL) in recent reports.

With less morbidity such as colic pain, hematuria and renal injury using early-generation shock wave lithotripter, the new generation of extracorporeal shock wave lithotripter is more effective for management of ureteral calculi (80% stone-free rate in 3 months).[12] However, endoscopic management such as ureteroscopy (or percutaneous nephrolithotripsy [PCNL]) has a higher stone-free rate of 97–100%, and it is especially needed for large ureteral

calculi, calculi located at the ureteropelvic junction, polyp formation, and stenotic or kinked ureter that prevents smooth passage of stone fragments.[1,12] Finally, for rare cases that are not cured by ESWL or endoscopic surgery, traditional open surgery should always be considered, which results in different types of complications.

2. Minor Complications

Minor complications, such as flank pain, dysuria, hematuria, "pushed-back" stone, dislocation of double-J catheter, forgotten catheter and submucosal stones, are not uncommon. Minor complications account for 87.5–92% of the overall complications in ureteral stone surgery.[4,10] It is not about the success rate of surgery but rather the minor complications that will increase the morbidity and patient's discomfort. Upward migration of a double-J catheter needs to be managed by ureteroscopy and ureteral stone forceps. Basket forceps is another option if a ureteral stone forceps is not available. For a larger pushed-back stone, ESWL is the first treatment of choice. A forgotten ureteral catheter with stone formation can be easily treated with ESWL or ureteroscopic surgery. However, severe encrustation leads to renal impairment. After removal of an internal stent, submucosal stones can increase the risk of ureteral obstruction, which might be symptomatic and require further ureteroscopic surgery, long-term ureteral catheterization or even open surgery.

Minor complications can become major complications under some specific conditions; therefore, we should try to perform all regular ureteral stone surgery as well as possible. Before surgery, patients should be informed about all the possible complications as clearly as possible, and should be included in the informed consent form.

3. Major Complications

The incidence of major complications, which include stricture, perforation, and avulsion of the ureter have significantly decreased owing to small-caliber instruments, increased use of flexible ureteroscopes, improved intracorporeal lithotripters, and increased experience of ureteroscopy. In recent studies after the year 2000, such major complications accounted for only 0.8–1.6% of the overall complication rate associated with ureteroscopic surgery for ureteral stones.[1,6,7]

The highest incidence of perforation has been noted using electrohydraulic lithotripsy. Preoperative evaluation is important, because some factors such as large stones, complete obstruction or long duration of obstruction might increase the risk of polyp formation, stricture, severe adhesion between the stone and mucosa, or deformity of the ureter. If the surgeon fails to pass the safety guidewire through the segment of the ureter with calculi obstruction, open surgery should be considered, because a large number of stone fragments and bleeding might blur the endoscopic field. The operation time becomes longer, and perforation usually occurs during manipulation of stone fragments. To avoid fluid extravasation that can aggravate morbidity, the operation should be ended immediately when perforation occurs. In our experience, percutaneous nephrostomy drainage during ureteroscopic surgery for large, long-term impacted stones is helpful to prevent severe complications or failure of endoscopic surgery. Small perforations might heal by themselves with adequate drainage for at least 4–6 weeks.[6] The patients should be followed up closely for possible abscess formation.

Ureteral avulsion is the most severe complication of the ureter and usually happens when the surgeon is trying to remove a large stone through a narrow ureteral lumen. Using basket forceps for stone removal has a higher risk of antegrade ureteral avulsion than using a stone grasper. Stone retrieval should be always performed carefully under direct vision. When avulsion occurs, immediate open repair achieves a better outcome than delayed diagnosis and delayed repair. In cases with a short segment of avulsion, a long duration of ureteral stenting, for several months, could be successful. However, ureteral stricture as a late complication occurs in most cases. A different type of avulsion occurs retrogradely with calculi that are located higher in the ureter close to the kidney. This condition is usually associated with fragile ureteral mucosa due to infection, or a narrow ureteral orifice. Although the ureteroscope is small at the tip, it is large at the proximal part. When the ureteroscope travels upward for upper ureteral calculi, the operator can feel the tightness of the ureter, and difficulty in moving the ureteroscope before avulsion occurs. At this point, it is advisable to stop the procedure, and withdraw the ureteroscope slowly under direct vision. It is helpful in such cases to use a balloon catheter for dilatation of the ureter before trying again.

Ureteral stricture with or without residual stones can be a problem for patients and their urologists for many years, even for the patients' lifetime. Regular replacement of ureteral stents at the outpatient department (OPD) is an uncomfortable but acceptable treatment for severe ureteral stricture. Other associated complications include vesicoureteral reflux, hydronephrosis, infection, hematuria, and stone formation. Laser treatment for small segments of stricture is helpful. For patients with long segments of stricture that cannot be drained with an internal stent, percutaneous drainage should be done initially to preserve renal function. After detailed evaluation, such as antegrade pyelography and retrograde ureterography, further surgical repair should be considered.

4. Distal Ureteral Calculi

Although ESWL provides a noninvasive, simple and safe option, URSL remains the most effective procedure for distal ureteral calculi.[13–15] A recent long-term study of ureteroscopic management for lower ureteral calculi

showed a significant decrease in overall complication rate from 15.1% (year 1991–1996) to 4.1% (year 1996–2005).[3] The major complication rates were 0.5% for ureteric perforation, 0.1% for ureteric avulsion, 0.2% for residual stones, and 0.1% for ureteral stricture.[3] The overall success rate for ureteroscopic stone extraction improved from 85.7% to 97.3%.[3] As the techniques have improved, URSL for lower ureteral calculi has become highly effective and safe. The rapid attainment of stone-free status has become a significant advantage for primary URSL. However, a higher incidence of minor complications, such as flank pain and dysuria, has been noted in the ureteroscopy than ESWL group (25% *vs.* 9%).[16] Distal ureteral stones, which account for 60% of all ureteral stones, are generally treated with a rigid ureteroscope, which has several advantages compared with a flexible ureteroscope, such as easier stone manipulation and a larger working channel for better irrigating flow and visualization.[6]

When comparing URSL with ESWL, most authors agree that both modalities have high efficacy and low complication rates.[16–19] The success rate of ESWL for ureteral calculi is machine-dependent. A higher stone-free rate and lower retreatment rate have been noted with the Dornier HM3 lithotripter.[14,20] Taking into consideration patient acceptance and preference, ESWL as primary treatment of distal ureteral calculi is reasonable in patients with intractable pain or high surgical risk. Smaller distal ureteral calculi (surface area, $<50\,mm^2$) can be treated with ESWL as the first option, and URSL is appropriate for larger calculi.[21] However, URSL is more cost-effective than multiple sessions of ESWL.[22] For lower ureteral calculi >1 cm in diameter, URSL is the optimal treatment, but ureterolithotomy is still a reasonable alternative method.[23]

5. Proximal Ureteral Calculi

The treatment of proximal ureteral calculi is always a challenge to the urologist because of the lower stone-free rate and higher complication rate by URSL compared with distal ureteral calculi. Parker et al.[24] have shown that the success rate for initial treatment of proximal ureteral stones was higher by URSL than ESWL (91% *vs.* 55%), with similar complication rates. That study has demonstrated that URSL is more efficient and cost-effective than holmium:YAG laser for proximal ureteral stones ≥ 1 cm in diameter. However, more recent studies have claimed that ESWL should be considered as the first-line treatment for ureteral stones because of its noninvasive nature, its causing less pain, and patient preference.[12,25,26] Pedro and Netto[25] have reported a complication rate of 13% for ESWL of ureteral stones in 121 patients, which included flank pain, gross hematuria, and fever. Ziaee et al.[12] have reported fewer complications of intractable pain (2 of 126) and fever (3 of 126), which resulted in hospitalization after ESWL for proximal ureteral stones of 10–15 mm in diameter, compared with ureteroscopy surgery. In these studies (year 2006–2008), no major complications were reported.[12,25,26]

Experience in holmium laser lithotripsy has shown high stone-free rates for different locations of stones: 98%, 100% and 97% for stones in the distal, middle and proximal ureter, respectively.[1] Stone size and location are not predictive factors for complications and success.[27] Experienced surgeons have lower complication rates, and their success rate is higher. In recent studies, significantly higher complication rates have been noted for lower ureteral than proximal stones (16.9% *vs.* 3.2%), especially those treated by laser lithotripsy.[27,28] Current laser lithotripsy and ESWL machines have better fragmentation ability that decreases the risk of ureteral avulsion by unnecessary stone basketing from the upper ureter. For proximal ureteral stones, Krambeck et al.[6] have reported an increase in flexible ureteroscopy from 12% in 1992 to 37% in 2006, an increase in laser lithotripsy from 6.5% to 48.7%, and a decrease in basket extraction from 69.4% to 47.7%.

For larger proximal ureteral stones that have a poor response to ESWL or URSL, PCNL is an alternative therapeutic option with different complications, such as renal pelvic perforation, ureteral avulsion, blood loss, hemothorax, hydrothorax, and adjacent organ damage. In our experience, puncture through the posterior upper calyx greatly facilitates the approach and removal of ureteral stones located at the L2–L4 level. A small Amplatz sheath and ureteroscope are helpful in decreasing the incidence of complications such as injury to the ureteropelvic junction, long-term stricture, and obstruction.

6. Outpatient Ureteroscopic Surgery

Outpatient ureteroscopic stone extraction, particularly for distal ureteral calculi, was performed successfully with low morbidity by Harmon et al.[5] in 1997. Cheung et al.[28,29] have undertaken several studies on outpatient ureteroscopy since 2000. Their studies have started a nationwide trend towards outpatient treatment, from only 50% in 1992 to 76.2% in 1998. The stone extraction rate decreased from 94.4% in 1992 to 88.5% in 1998. They also have found that URSL can treat stones >10 mm in diameter at all levels safely and effectively in an outpatient setting, with a low rate of major complications (0.46%).[28]

Holmium:YAG laser combined with small rigid or flexible endoscopes has been shown to be a highly effective and safe treatment for ureteral calculi in 590 of 598 outpatients (99%).[1] Improvements in ureteroscope design, accessories and technique, and increased experience have led to a significant increase in the success rate and decrease in the complication rate. Pearle et al.[16] have reported that 75% of patients with distal ureteral calculi who received ureteroscopy were discharged home on the day of the procedure. The length of hospital stay has decreased from 2.5 days before 1995 to 0.5 days after

1996, which means a trend towards outpatient treatment for ureteral stones.[3]

Osorio et al.[30] have treated 144 patients with obstructive ureteral stones by emergency ureteroscopy and stone retrieval, with findings of an overall stone-free rate of 92.4% (94.6% for distal and 71.4% for proximal stones) and an overall complication rate of 4.2%.[30]

7. Large Ureteral Calculi

URSL is safe and effective for stones at all levels of the ureter; however, a higher complication rate has been noted for stones > 10 mm in diameter (22% *vs.* 5.4%).[29] There is no significant difference in complication rates when comparing ESWL for ureteral stones larger than 10 mm. However, URSL is more efficient and cost-effective than ESWL.[24] Recent studies have shown that ESWL has sufficient capacity for the management of large ureteral stones, but URSL tends to make stone removal faster.[12,23] With a small-caliber ureteroscope and holmium:YAG laser, 87% (47 of 54) of patients with ureteral stones > 20 mm in diameter were treated successfully by a single procedure.[31] Laparoscopic ureterolithotomy is an uncommon surgical procedure for ureteral stones because of a limited number of indications, such as large impacted stones for > 2 months duration that have failed treatment with ESWL and URSL.[32,33] Goel and Hemal[32] have reported 55 patients with large stones (mean diameter, 21 mm) who underwent retroperitoneal laparoscopic ureterolithotomy. The complications encountered were one injury to the external iliac artery, three peritoneal tears, two cases of fever, two wound infections, and 10 conversions to open surgery. Guar et al.[33] also have reported a high complication rate of 31% because of prolonged urinary leakage (20 of 93 patients).

8. Open Surgery

With advances in endourology, the indications for open ureterolithotomy have decreased considerably from 26% in 1987–1995 to 8% in 1996–1998. Kehinde et al.[4] have reported that only 3% (41 of 1383) of patients with ureteral calculi were managed by ureterolithotomy. Matlaga and Assimos[34] have reported that only 0.7% (7 of 987) of open surgical procedures from 1998 to 2001 were due to anatomic abnormalities or repeated failure of endoscopy. Of all open procedures, the percentage of ureterolithotomies decreased from 62% in 1989 to 0% in 2001.[34] However a higher complication rate was noted in this group (13–32%) compared with the endoscopic therapy and ESWL groups.[4,35]

In our experience, exploration of the retroperitoneal space by lumbotomy for large, impacted upper ureteral and ureteropelvic junction stones is a safe and effective procedure with minimal wound pain and a low frequency of complications.

9. Management of Complications

Ureteroscopy has become a popular and effective way to manage ureteral calculi, but it has led to a large number of iatrogenic complications. Perforation is the most common complication of ureteroscopic surgery. Prolong ureteral stenting with or without percutaneous nephrostomy is the first option for minor injuries. However, immediate open surgery is necessary for severe injury. There are various methods for treating ureteral stricture formation, such as balloon dilatation, ureteral meatotomy, renal mobilization, ureterocalicostomy, ureteroureterostomy, transureteroureterostomy, ureteroneocystostomy, psoas hitch, Boari flap, ileal ureter, and renal autotransplantation.[36] The choice of procedure depends on the location and type of injury, the function of the contralateral kidney, and the experience of the surgeon. For severe iatrogenic ureteral injuries, laparoscopic nephrectomy with autotransplantation has been performed to preserve renal function, with acceptable morbidity.[37]

10. Prevention of Complications

In our personal experience, non-contrast computed tomography (CT) for diagnosis of renal colic induced by small or radiolucent stones is very helpful. In 1995, Smith et al.[38] evaluated the utility of CT for identifying ureteral calculi, and concluded that CT is more effective than intravenous urography. Later studies have shown that CT detects ureteral calculi with a sensitivity and specificity from 98% to 100%.[39,40] Non-contrast CT is good for rapid, accurate diagnosis of ureteral stones; therefore, we have found that the rate of "no stone, or passage of stone" is significantly lower than before the use of CT as a diagnostic tool. We believe that some unnecessary morbidity and complications have been avoided by unnecessary surgery.

The incidence of ureteral avulsion has decreased from 0.5% in 1987 to 0% in 2001.[6,41] It is clear that severe ureteral injury can be avoided with careful practice and sufficient experience in diagnosis and management. Severe injuries usually occur when extracting impacted or large stones with excessive force. Upper ureteral stones are associated with a greater possibility of complications than lower ureteral stones, and thus might be better treated with ESWL or laser lithotripsy.[27] Passage of a safety guidewire to the renal pelvis, good preoperative intravenous urography imaging, maintenance of clear visibility of the ureteral lumen during ureteroscope advancement, and dilatation of tight intramural ureters are all helpful in the prevention of complications.[36]

The use of a ureteral access sheath has been demonstrated to decrease operative time and maximize longevity of the flexible ureteroscope, especially in difficult cases such as impacted or complex ureteral stones that require repeated ureteroscope insertion. As a result of the low complication rate, it has not been possible to determine

whether the use of a ureteral access sheath alters complication rates.[6] Several suggestions have been made to decrease potential complications, such as the choice of an appropriate sheath based on the patient's anatomy and expected function, dilatation of the intramural ureter before insertion of the sheath, and removal of the sheath under direct vision, which allows the surgeon to inspect the urothelium for perforation or bleeding.[2] In the study of Sprunger and Herrell,[2] ureteral dilatation was performed in 54.2% of 1000 cases of ureteroscopy, with a ureteral stricture rate of only 0.2%. Chow et al.[42] reported similar complication rates in 1992 (12%) and 1998 (10.2%), in spite of the increased use of flexible ureteroscopes from 11.5% in 1992 to 29.4% in 1998.

11. Forgotten Catheter

The forgotten catheter can become a major complication when it results in large encrusted stones in the bladder, ureter and kidney, which present a management challenge. Mohan-Pillai et al.[43] have demonstrated that stone-encrusted ureteral stents can be successfully managed with combined ureteroscopy and PCNL therapy. Complete removal of the ureteral stent is the goal of therapy in such patients, with little invasion and damage to the urinary tract. It takes a long operative time (6–8 hours) to remove all the stones and the catheter by endoscopic surgery (including cystolithotripsy, ureterolithotripsy, and PCNL). For operative and anesthetic safety, staged therapy should be considered in high-risk or aged patients.

12. Ureteral Dilatation

In the current practice of ureteroscopy with the small-caliber ureteroscopes, it is often unnecessary to dilate the ureter. However, the surgeon still should assess the need for dilatation of the distal ureter under some conditions, in approximately 14–54.2% of cases.[5,6] Dilatation should be performed if multiple passes of the ureteroscope are necessary or if the ureteroscope cannot be negotiated easily into the upper urinary tract.[2] Retrograde degloved ureter, a rare but severe complication, usually occurs in patients with upper ureteral stones, with a narrow ureteral orifice. Distal ureteral stricture following orifice dilatation is usually associated with fascial dilators or metal bougies.[44] Garvin and Clayman have demonstrated no long-term clinical sequelae from routine ureteral orifice balloon dilatation.[45]

13. Stent or No Stent?

For large renal and ureteral stones, placement of ureteral stents before ESWL could decrease the risk of Steinstrasse, colic pain, and hydronephrosis.[31,46] However, patients with ureteral stents usually suffer from flank pain, dysuria, and hematuria. The surgeon has to remind the patient to remove the internal drainage tube. To remove the internal stents easily and reduce the morbidity of OPD cystoscopy, we tried to place a string tail at the distal end of the double-J catheter by 5-0 nylon suture fixation. In this way, we removed the double-J catheters at OPD smoothly from 71 patients who underwent ureteral stone surgery in 2008–2009. Some complications, such as incidental tube loss (1 of 72), urinary incontinence (5 of 72), and urethral irritation (31 of 72) were noted. Incidental tube loss occurred in one female patient just after surgery. One female and four male patients had urinary incontinence 2–5 days after the operation because of downward dislocation of the double-J catheter. Our present strategy has been modified in that the string tail procedure should only be performed in male patients after extensive discussion of the possible complications. Routinely, no urethral catheter after ureteroscopic surgery is a key element in this strategy. The procedure is favored for cases that have had a history of repeated ureteral stone surgery rather than first-time cases. Good communication and education of patients before stenting is always necessary. On an outpatient basis, Sofer et al.[1] have performed ureteroscopic holmium:YAG laser lithotripsy in 590 patients with upper urinary tract calculi, mostly in the ureter. Overall, 430 (72%) were stented postoperatively. In that study, no patients without a stent had complications, such as colic or sepsis, that necessitated postoperative stent insertion. Postoperative ureteral stenting is unnecessary in certain cases.

14. Urine Leakage

Small amounts of retroperitoneal urine leakage can be absorbed gradually without any complication. In patients with large urinoma, percutaneous pigtail drainage is indicated when it becomes symptomatic, such as intractable pain or abscess formation. In our experience, a more difficult situation arises if urine leaks into the abdominal cavity as a result of ureteral surgery. This usually happens when open surgery is performed for severe ureteral injury or stricture. Persistent urine leakage into the abdominal cavity induces severe ileus, vomiting, and poor nutritional status, although the symptoms can subside gradually after conservative treatment, such as fluid limitation, keeping flexion position, adequate drainage, and negative pressure suction. There are some techniques for prevention of urine leakage, such as tension-free approximation of the ureter, internal stent placement, and water-tight suture. We have tried three-way urethral catheterization with lower pressure suction in a patient who had double-J stenting that was complicated with intra-abdominal urine leakage. Abdominal drainage significantly decreased the amount of urine, which led to satisfactory recovery. Careful evaluation and avoidance of intra-abdominal repair

of ureter is helpful in prevention of such a severe complication. If open surgery is necessary, retroperitoneal repair is always a better choice.

15. Ureteral Calculi in Pregnancy

Ureteral stenting is often the first treatment of choice for renal colic in pregnancy because of difficulty in diagnosis and surgical risk to the fetus. Lifshitz and Lingeman[47] have reported that ureteroscopy was a safe and effective procedure when performed without complication in six pregnant women. A review and analysis of the safety of ureteroscopy during pregnancy from 2002 to 2007 have shown that nine complications (8.3%) occurred in 108 women, including two with postoperative pain, five with urinary tract infection, one with ureteral perforation and one with premature uterine contraction.[48] This analysis has shown that the complication rate is low, and the safety of ureteroscopy and stone removal in pregnant women is not significantly different from the safety of the same procedure in non-pregnant patients.

16. Pediatric Ureteral Calculi

Recent reviews have revealed that shock wave lithotripsy, percutaneous nephrolithotomy and ureteroscopy are highly effective endourologic techniques to treat stone disease in the pediatric population.[49,50] Ureteroscopy for the treatment of urolithiasis had been performed in the pediatric population in an increasing number of centers. The stone-free and complication rates of URSL are comparable with those of ESWL.

17. Conclusion

Our review shows that there are two trends in surgery for ureteral stones worldwide. The first change is an increase in outpatient treatment by ureteroscopy, with the same success and complication rates as with inpatient treatment. The other change is an increase in the use of flexible ureteroscopy and holmium laser lithotripsy, which are especially beneficial for proximal ureteral calculi, with fewer complications than for lower ureteral calculi. These developments have not been so clear in Taiwan because of cost factors. With advancements in modern technology and new equipment, more options are available for surgeons and patients. Different types of complications can arise as a result of learning and practicing new techniques for ureteral surgery; however, a large prospective study is needed.

Regardless of stone size and location, experience of the surgeon is the only predictive factor for complication and success rates. We must learn to recognize the potential risks, such as acute pyelonephritis, large stones, and long duration of impaction. We also need to be aware of the possibility of unusual complications of surgery for ureteral stones and prepare for second-line treatment such as percutaneous drainage.

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