Clinical Perspective

Is there still a need for open/laparoscopic surgery for urinary stones?

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Practice points

- A nonfunctioning kidney chronically affected by a staghorn calculi should be removed, ideally laparoscopically.
- The nonfunctioning lower/upper pole of a kidney chronically affected with calculi should be removed, ideally laparoscopically.
- Ureteropelvic junction obstructions and concomitant kidney stones should have both a laparoscopic pyeloplasty and a pyelolithotomy. If a large stone burden is present an alternative option is an antegrade endopyelotomy combined with a percutaneous nephrolithotomy.
- Anterior calyceal diverticula if large, may be treated with a laparocopic/open resection.
- Laparoscopy can be used to facilitate the placement of a percutaneous renal tract for the treatment of renal calculi in a pelvic kidney.
- In exceptional situations anatrophic nephrolithotomy, ureterolithotomy and cystolithotomy may be required.

SUMMARY Over the past 30 years the treatment of renal calculous disease has changed dramatically. With the advent of extracorporeal lithotripsy and the advances in ureteroscopy, and percutaneous nephrolithotomy, the need for both open and laparoscopic treatments for renal stone disease has been virtually eliminated. In spite of these advances in technology and technique there still remains a small but crucial role for open and laparoscopic treatments for renal stones. The goal of this article is to identify specific clinical scenarios that would require an open/laparoscopic approach for the treatment of kidney stone disease.

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The surgical treatment of renal calculous disease has progressed significantly over the past 30 years. Since the introduction of extracorporeal shockwave lithotripsy (ESWL), the management of renal stones has changed dramatically. Additionally, the advances in ureteroscopic and percutaneous techniques have led to the virtual extinction of both open and laparoscopic treatments of renal stones. At most urological centers in the world, the open/laparoscopic treatment of stones accounts for between 1 and 5.4% of renal stone therapies [1–5]. In 2000, only 2% of Medicare patients undergoing treatment for stone disease were treated with open surgery [6]. With advancing technology and increasing expertise, the list of indications for open/laparoscopic treatments of renal stone disease has grown even smaller. In general, smaller renal stones can be treated with ureteroscopy or ESWL and larger renal stones are treated with percutaneous nephrolithotomy (PCNL). Additionally, in general, ureteral stones can be treated with either ureteroscopy or ESWL. The goal of this article is to identify specific clinical scenarios that would warrant an open/laparoscopic approach for the treatment of renal stone disease.

To date, open/laparoscopic treatments are indicated for nonfunctioning kidneys containing calculi, for kidneys with stones and concomitant anatomic abnormalities (calyceal diverticulums and ureteropelvic junction obstructions [UPJOs]) and for ectopic kidneys with simultaneous calculi. In exceptional situations anatrophic nephrolithotomy, ureterolithotomy and cystolithotomy may be required.

The nonfunctioning kidney

The most straightforward indication for the open/laparoscopic treatment of renal calculus disease is for kidneys that lack function. In rare situations in which a patient is chronically affected by a staghorn calculus, which secondarily causes renal obstruction leading to the loss of renal function, a nephrectomy (open or laparoscopically) can be performed. This indication becomes even clearer when the nonfunctioning kidney is associated with recurrent infections and/or bleeding [7]. The principle problem is that the poorly functioning kidney can serve as a nidus for persistent and recurrent infections [8–11]. It should be made clear that the primary option for the treatment of a staghorn calculus is PCNL; however, when the kidney is no longer functioning, nephrectomy is a viable and attractive option.

In certain situations, renal stones can accumulate in one of the two poles of the kidney (i.e., upper or lower) and in doing so they can cause a loss of renal function in either of these poles. In this specific situation, a partial nephrectomy (open or laparoscopically) can be performed in order to remove the stones along with the nonfunctioning portion of the kidney.

Before performing a nephrectomy or partial nephrectomy, the patient should undergo a nuclear medicine study to evaluate the function of the kidney including its upper and lower poles. This will help to determine whether the kidney or part of it must be removed. It is important to note that since the kidney is chronically infected a laparoscopic technique may be difficult. That being said, depending on the surgeon's experience and preference, both a laparoscopic or open approach are acceptable.

The kidney with anatomic abnormalities

One of the main indications for the open/laparoscopic treatment of renal calculous disease is for patients who have concomitant UPJOs. UPJOs can be repaired (pyeloplasty) by removing the narrowed region of the proximal ureter or by moving the ureter in front of an obstructing vessel. In experienced hands this procedure is performed laparoscopically. For patients with UPJOs and concomitant renal stones, repair of their UPJOs can be accomplished at the same time as removal of their stones. The reported success rate for laparoscopic repair of UPJOs is above 90% [12–14]. Furthermore, the simultaneous removal of renal calculi and UPJO repair has also been reported and has displayed very high success and stone-free rates [15,16]. The alternative to pyeloplasty with concomitant stones removal is percutaneous nephrolithotomy and antegrade endopyelotomy. This can also be very effective as a treatment modality [14]. However, the success rate of the endoscopic technique is lower than that of the laparoscopic technique **(Table 1)** [14,17,18]. The decision to use one technique over the other is not only based on the expertise of the surgeon but also on the quantity of stone within the kidney. With minimal stone within the kidney, pyeloplasty with stone removal is a good option. However, with a large stone burden, it is the author's opinion that laparoscopic

Table 1. Comparison of laparoscopic pyeloplasty and antegrade endopyelotomy.

Procedure	Patients (n)	Success rate (%)	Follow-up (mean unless otherwise stated)	Ref.
Endopyelotomy				
Primary antegrade endopyelotomy	38	92	16 months	[14]
	182	63, 55, 41	3, 5 and 10 years (respectively)	[18]
	60	65	55 months	[45]
	75	55.4	31 months	[46]
	113	72.6	63 months	[47]
Secondary antegrade endopyelotomy	12	58	16 months	[14]
	19	74	55 months	[45]
Laparoscopic pyeloplasty				
Primary laparoscopic pyeloplasty	29	100	16 months	[14]
	175	85, 80, 75	3, 5 and 10 years (respectively)	[18]
	90	95.3	28.5 months	[46]
	143	94.4	63 months	[47]
Secondary laparoscopic pyeloplasty	21	95.2	16 months	[14]

removal and pyeloplasty becomes more difficult. Therefore, in a kidney with a large stone burden a percutaneous approach with antegrade endopyelotomy is preferred. This includes partial and full staghorn calculi, as well as patients with a large number of stones.

Another anatomic abnormality that can be treated with an open or laparoscopic technique is calyceal diverticula. Calyceal diverticula are congenital abnormalities caused by arrested regression of ureteric buds [19]. A laparoscopic/open treatment may be indicated, especially if the diverticulum is anteriorly located [20]. This is due to the fact that with the diverticulum in an anterior location, PCNL becomes more difficult. Therefore, when the diverticulum is posteriorly located a PCNL should be the treatment modality of choice as opposed to an open/laparoscopic procedure as both have similar success rates, but PCNL is associated with less morbidity [21,22]. The laparoscopic approach is preferred to an open approach due to the decreased morbidity. Furthermore, the laparoscopic approach has been found to be extremely effective with minimal risk of calyceal diverticula recurrence [23].

The ectopic kidney

The overall incidence of kidney ectopia is approximately one in 900. Renal ectopia is associated with intra-abdominal organ displacement as well as abnormal intra-abdominal spatial relationships between the kidney and other organs. This modification in intra-abdominal organ organization can make stone treatment difficult. Small renal stones can be treated with ESWL or ureteroscopy. However, when larger stones are present ESWL becomes a less attractive option and ureteroscopy must be done in a staged fashion requiring multiple anesthetic events. PCNL while effective, may increase the risk of injury to the abdominal viscera and/or aberrant vessels. In these cases laparoscopic-guided PCNL becomes a viable option or laparoscopic pyelolithotomy can be performed [24,25]. In 1985, Eshghi *et al.* were the first to report on the laparoscopic treatment of renal stones in a pelvic kidney [26]. Elbahnasy *et al.* looked at the use of laparoscopic pyelolithotomy for the treatment of large and multiple stones in ectopic pelvic kidneys. In 11 patients they found that this technique allowed for the removal of all stones without fragmentation [25]. Numerous other authors have looked at the benefit of using laparoscopy to aid in the placement of a percutaneous renal tract for the treatment of renal calculi in a pelvic kidney [24,27–31]. Holman *et al.* reported on a series of 15 patients treated with transperitoneal laparoscopic percutaneous nephrolithotomy [30]. They demonstrated a 100% success rate with minimal morbidity. Additionally, Troxel *et al.* reported on one case of successful extraperitoneal laparoscopy-assisted percutaneous nephrolithotomy in a left pelvic kidney [31]. Both these approaches have been shown to be extremely effective at safely placing a percutaneous tract into the kidney. As these methods are done under direct vision they reduce the risk of inadvertently injuring abdominal viscera and/or aberrant blood vessels. Alternatively,

computed tomography-guided access may be considered [22].

Anatrophic nephrolithotomy

Anatrophic nephrolitotomy is a procedure whereby an incision is made along the intersegmental plane of the kidney [32]. According to the most recent American Urological Association guidelines, the main indication for this procedure is in patients with extremely large stones with concomitant complex collecting systems [7]. Lam and colleagues reported that when the stone surface area was greater than 2500 mm^2, the chance of achieving stone-free status with a percutaneous approach was only 54% [33].

The success of an anatrophic nephrolithotomy is in the identification of the intersegmental plane. In order to determine the location of this intersegmental plane, the posterior segmental artery is first isolated from the main renal artery. Once the posterior segmental artery is isolated, it is clamped and 20 ml of methylene blue is injected into the patient. The methylene blue demonstrates a demarcation between the pale area of the kidney (posterior segmental area) and the surrounding blue-tinged perfused area of the kidney. After the institution of ischemic hypothermia an incision is made along the intersegmental plane and the stones are removed [32].

Anatrophic nephrolitotomy is associated with significant morbidity including atelectasis, pneumothorax, pulmonary embolism, wound infection, acute tubular necrosis, rhabdomyolysis, hemorrhage, vascular injury and urinoma [32].

In order to reduce the mobidity associated with anatrophic nephrolithotomy, Simforoosh *et al.* reported their results of laparoscopic anatrophic nephrolithotomy. The mean stone size removed was 5.3 cm in five patients. No complications were reported with an average hospital stay of 5.4 days. However, two out of the five patients did have residual stones [34].

In summary, anatrophic nephrolithotomy should only be used in very select cases (extremely large stones and complex collecting system anatomy) by surgeons experienced with this technique. In the majority of situations PCNL should be favored.

Ureterolithotomy

According to the 2007 American Urological Association ureteral calculi guidelines, ureterolithotomy should not be a first-line treatment. However, in rare cases where ESWL, ureteroscopy and PCNL fail or are unlikely to be successful, an open or laparoscopic ureterolithotomy can be considered. The guidelines also mention that an open or laparoscopic ureterolithotomy can be considered in situations of large impacted ureteral stones, multiple ureteral stones or in cases where a concurrent condition requires an open or laparoscopic approach [35].

Numerous studies have confirmed that laparoscopic ureterolithotomy is as effective as an open approach with less associated morbidity [36–39]. Therefore, if a ureterolithotomy is required, it should be performed laparoscopically, if possible. Laparoscopic ureterolithotomy can be performed transperitoneally [38] or retroperitoneally [39]. The retroperitoneal route, which is the most common route, avoids contamination of the peritoneum with potentially infected urine. However, compared with the intraperitoneal approach, the operating space available in the retroperitoneum is limited and may be challenging. Conversely, space in the peritoneum is not an issue, however the risk of bowel injury is a possible complication of the transperitoneal approach [40]. Both the laparoscopic and the open techniques should include the placement of a ureteral stent and a surgical drain in order to avoid prolonged leakage from the surgical site [41].

Overall, the stone-free rate of open or laparoscopic ureterolithotomy is above 90% [36–39]. Ureterolithotomy is not without complications and these include bleeding, prolonged urinary leakage and ureteral stricture [36–39].

In summary, ureterolithotomy (laparoscopic or open) should not be used as a first-line treatment, however, in very select patients this treatment can be very effective with a high stone-free rate.

Cystolithotomy

Open cystolithotomy is a procedure that is rarely used today in the adult population. It is a technique that has a very high success rate but has been replaced by other very successful techniques including percutaneous cystolithotomy. The indications for open cystolithotomy include very large or hard bladder stones, abnormal anatomy that does not allow for safe percutaneous access, failure of an endoscopic approach or patients undergoing concomitant open surgery such as prostatectomy or diverticulectomy [42,43].

Although the use of open cystolithotomy is rare in the adult population, owing to numerous reasons it is still the gold standard in the pediatric population. The reason for this is threefold. First, in the pediatric male population the urethra is smaller and transurethral surgery may lead to future urethral problems including stricture. Second, open cystolithotomy allows for the removal of the entire stone without fragmentation; this avoids residual fragments, which may lead to bladder calculi recurrence. Finally, open cystolithotomy is the least expensive technique for removing large bladder calculi and since a majority of pediatric bladder stone cases are seen in developing countries, this becomes a very attractive option [44]. The stone-free rate of open cystolithotomy is 100% and complications are rare [44].

In summary, cystolithotomy provides a method of achieving a bladder stone-free rate of 100%. However it should not be a first-line treatment for bladder stones in the adult population except in very rare cases.

Conclusion

With the progression in techniques and technology and the increasing technical expertise of urologists around the world, the indications for open/laparoscopic treatments of renal stone disease have become rare. However, there are still specific vital clinical scenarios that will warrant an open/laparoscopic approach. Proper selection of these patients is crucial in order to obtain the most favorable surgical outcomes. Among those patients that should be considered for an open/laparoscopic approach are those with nonfunctioning kidneys (complete or partial), those with anatomic abnormalities and finally those with renal ectopia. In exceptional situations, anatrophic nephrolithotomy, ureterolithotomy and cystolithotomy may be required.

Future perspective

It has been almost 30 years since the first ESWL was performed in the USA. In this time the treatment of renal calculous disease has changed significantly. With the progression of the field of endourology and with the widespread acceptance of endourological techniques and technology, the future of renal stone disease should rely less and less on open/laparoscopic techniques. It is the opinion of this authors that virtually every ureteral as well as renal stone can be treated endoscopically in the hands of an experienced endoscopist.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

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