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Laparoscopic Surgery for Renal Stones: Is it Indicated in the Modern Endourology Era?

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ABSTRACT

Purpose: To report the outcomes of laparoscopic surgery combined with endourological assistance for the treatment of renal stones in patients with associated anomalies of the urinary tract. To discuss the role of laparoscopy in kidney stone disease.
Materials and Methods: Thirteen patients with renal stones and concomitant urinary anomalies underwent laparoscopic stone surgery combined with ancillary endourological assistance as needed. Their data were analyzed retrospectively including stone burden, associated malformations, perioperative complications and outcomes.
Results: Encountered anomalies included ureteropelvic junction obstruction, horseshoe kidney, ectopic pelvic kidney, fussed-crossed ectopic kidney, and double collecting system. Treatment included laparoscopic pyeloplasty, pyelolithotomy, and nephrolithotomy combined with flexible nephroscopy and stone retrieval. Intraoperative complications were lost stones in the abdomen diagnosed in two patients during follow up. Mean number of stones removed was 12 (range 3 to 214). Stone free status was 77% (10/13) and 100% after one ancillary treatment in the remaining patients. One patient had a postoperative urinary leak managed conservatively. Laparoscopic pyeloplasty was successful in all patients according to clinical and dynamic renal scan parameters.
Conclusions: In carefully selected patients, laparoscopic and endourological techniques can be successfully combined in a one procedure solution that deals with complex stone disease and repairs underlying urinary anomalies.

Key words: *kidney; laparoscopy; nephrolithiasis; genitourinary abnormalities*
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INTRODUCTION

Endourological techniques have revolutionized the treatment of urinary stones to the point they have rendered open stone surgery anachronistic (1). Procedures like open ureterolithotomy, open nephrolithotomy, or open pyelolithotomy have become anecdotal. However, patients with large stone burdens and associated renal malformations are prone to require multiple endourological procedures in order to have their stones retrieved and anomalies repaired. Thus in these selected patients, open stone surgery can certainly be considered reasonable (2). In centers with established experience in advanced reconstructive laparoscopy, this can be a feasible option if the goals of stone clearance and correction of malformations could be achieved in a single procedure. Incorporating laparoscopic techniques confer these patients surgical efficacy combined with the advantages of minimally invasive surgery.

In the present paper, we describe our experience and evaluate the outcomes of laparoscopic sur-

Table 1 *– Patients characteristics.*

N of Patients	Preoperative Diagnosis
6	UPJO + multiple pelvic and calyceal stones
2	UPJO + horseshoe kidney + multiple stones
1	UPJO + two stones 3 cm each in the renal pelvis + a calyceal diverticulum with a 2 cm stone
1	UPJO + ectopic pelvic kidney + 2 cm upper pole stone
1	UPJO + situs inversus + crossed-fussed ectopic kidney + tens of stones in lower moiety
1	UPJO + pelvic kidney + obstructive hydrocalyx + multiple pelvic and calyceal stones
1	Double collecting system + 9 cm complete staghorn stone in the lower moiety

UPJO = ureteropelvic junction obstruction.

gery in combination with endourological procedures involving a variety of cases of renal stones in the setting of underlying urinary tract malformations.

MATERIALS AND METHODS

The data of twenty-nine patients who underwent laparoscopic procedures for kidney stones between January 2004 and May 2007 were retrospectively analyzed. Retrieved data included indications for intervention, stone burden, associated malformations, perioperative complications and outcomes in terms of functional results and stone free status. Fifteen patients underwent laparoscopic nephrectomy due to non functioning kidneys and were not included in the present study. One patient underwent laparoscopic pyelolithotomy without harboring underlying malformations and thus was also excluded. The remaining thirteen patients underwent laparoscopic stone removal and reconstructive procedures combined with ancillary endourological assistance as needed. Preoperative stone scenario and associated anomalies are detailed in Table-1 and Figures-1 to 3. All cases were discussed with the endourology unit and considered unlikely that stones and underlying anomalies could be efficiently addressed with a single endourological procedure. Three patients had previous unsuccessful endourological procedures, with inability to gain percutaneous access and significant residual stones after nephroscopy among main causes of failure.

Patients underwent preoperative anatomical and functional evaluation with non contrast CT scan and either intravenous pyelography or diuretic renal scans in cases of suspected ureteropelvic junction (UPJ) obstruction. Postoperative assessment consisted of x-rays, ultrasound, and/or CT as appropriate. A diuretic renal scan was performed in patients who underwent concomitant pyeloplasty.

Surgical procedures and their technique are summarized below. Combinations were used to deal with specific patient necessities.

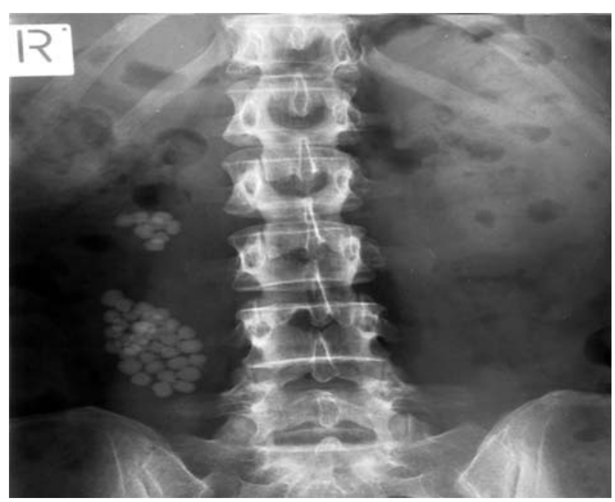

Figure 1 *– Patient with situs inversus and left to right crossed-fussed ectopic kidney with ureteropelvic junction obstruction and multiple stones in the ectopic kidney (lower moiety). This patient underwent laparoscopic pyelolithotomy and pyeloplasty.*

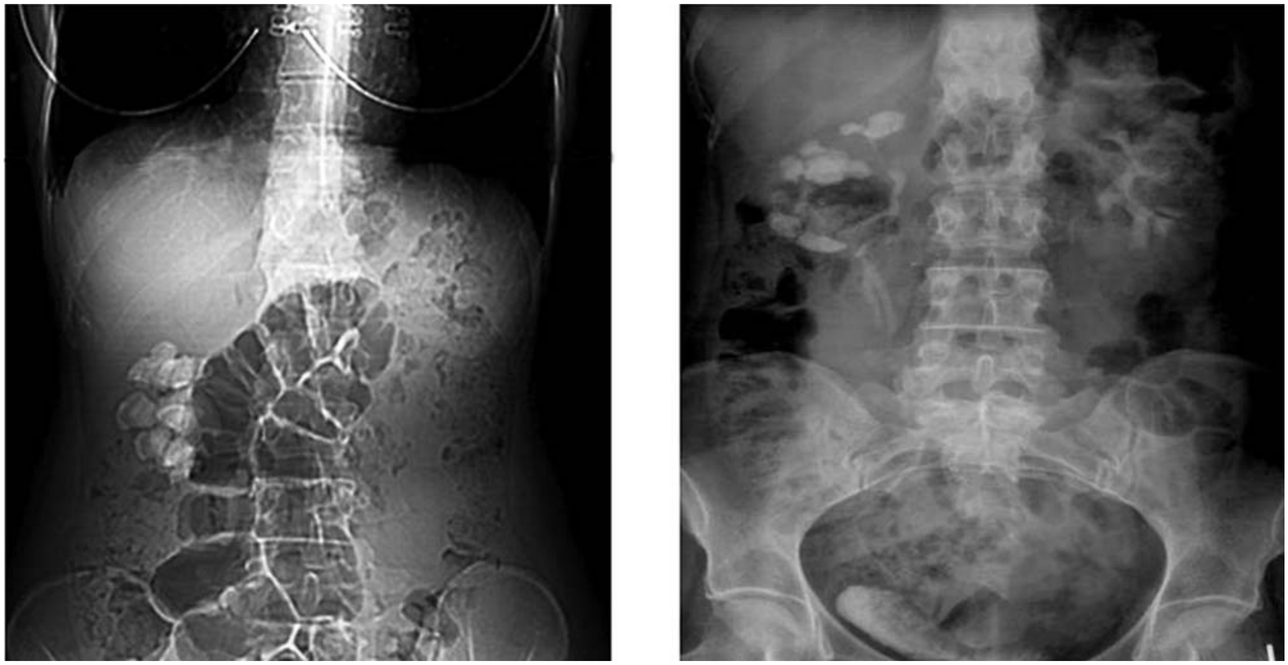

***Figure 2** – Left: Complete 9 cm staghorn stone in the lower moiety of a complete duplicated pelviocalyceal system. Right: Intravenous urography performed 3 months after laparoscopic anatrophic nephrolithotomy showing dye descending through both right excretory systems.*

SURGICAL TECHNIQUE

Laparoscopic Pyeloplasty and Pyelolithotomy / Flexible Nephroscopy

The operative room setting includes one laparoscopic cart and one endourological cart to enable simultaneous laparoscopy and nephroscopy. Using a four port transperitoneal approach, the ureter is identified and followed cranially, the UPJ is exposed and the renal pelvis dissected. The renal pelvis is opened above the UPJ, the ureter is spatulated on its lateral aspect and dismembered. Stones in the renal pelvis are removed with an atraumatic grasper and placed in a laparoscopic bag. A flexible cysto-nephroscope is passed through one of the 10 mm ports and guided laparoscopically through the opening in the renal pelvis. The kidney is systematically inspected and calyceal stones removed with a basket or fragmented with Holmium:YAG laser lithotripsy. A double J stent is introduced in an antegrade fashion, the renal pelvis is reduced as needed, and ureteropelvic anastomosis is performed with two (one posterior and one anterior) 4/0 polyglactin running sutures. A percutaneous drain is placed and the bag with stones removed (Figure-4).

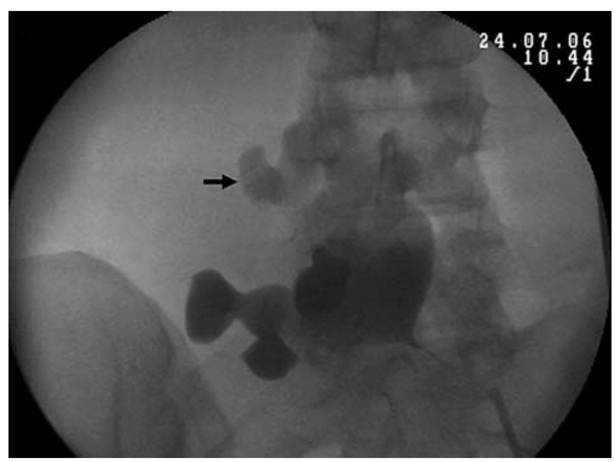

***Figure 3** – Retrograde pyelography of a patient with an ectopic pelvic kidney, ureteropelvic junction obstruction and a 2 cm stone in the upper pole (arrow). Intraoperatively, infundibular stricture was encountered and the patient underwent laparoscopic pyeloplasty, and "cut to the light" nephrolithotomy.*

Laparoscopic Nephrolithotomy

A "cut for the light" technique was used when calyceal stones were associated with infundibular stricture, obstructed hydrocalyx, or calyceal diverticulum. After widely incising the renal pelvis, the

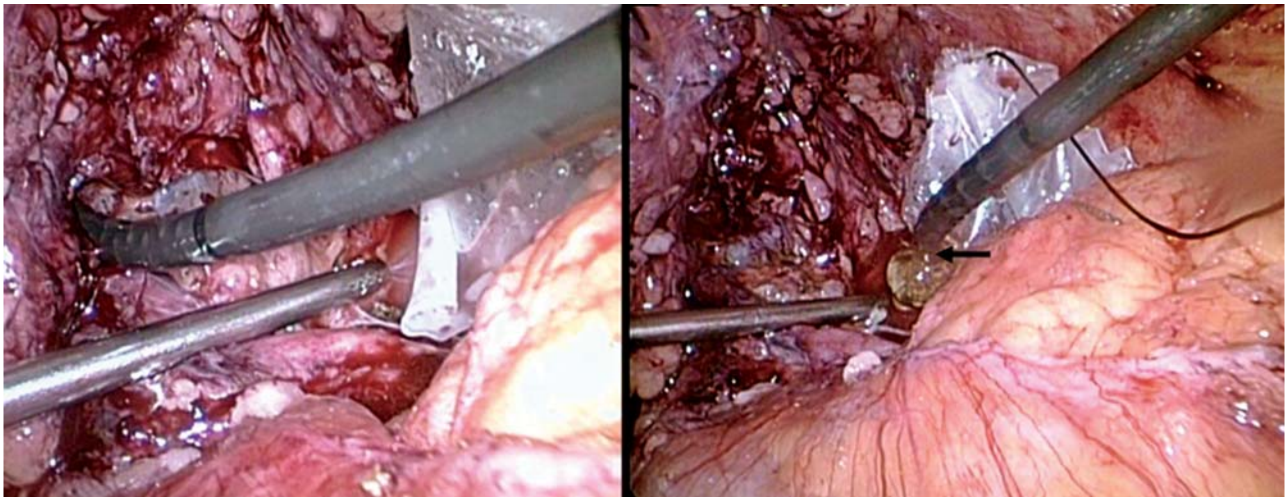

Figure 4 – Left: Flexible nephroscopy through the laparoscopic pyelothomy. Right: Basket extraction of encountered stones (arrow). Intermittent suction prevents fluid accumulation in the abdomen.

flexible cysto-nephroscope is brought at the obstructed calyx containing the stone and a small laparoscopic nephrotomy is made in the kidney as indicated by the endoscopic light. The stone is removed and the kidney sutured with one layer 2/0 polyglactin (Figure-5).

Laparoscopic Anatrophic Nephrolithotomy

The kidney is dissected from the surrounding fat, the vascular elements identified and clamped en bloc with a laparoscopic Satinsky clamp. The renal parenchyma and collecting system are incised longitudinally on the postero-lateral aspect of the kidney; the staghorn stone is mobilized with graspers, removed and placed in an endobag. A 16 F Foley catheter is placed as a nephrostomy tube by making a small incision in the kidney away from the nephrotomy line. The kidney is sutured with a running 2/0 polyglactin single layer that includes renal capsule, parenchyma,

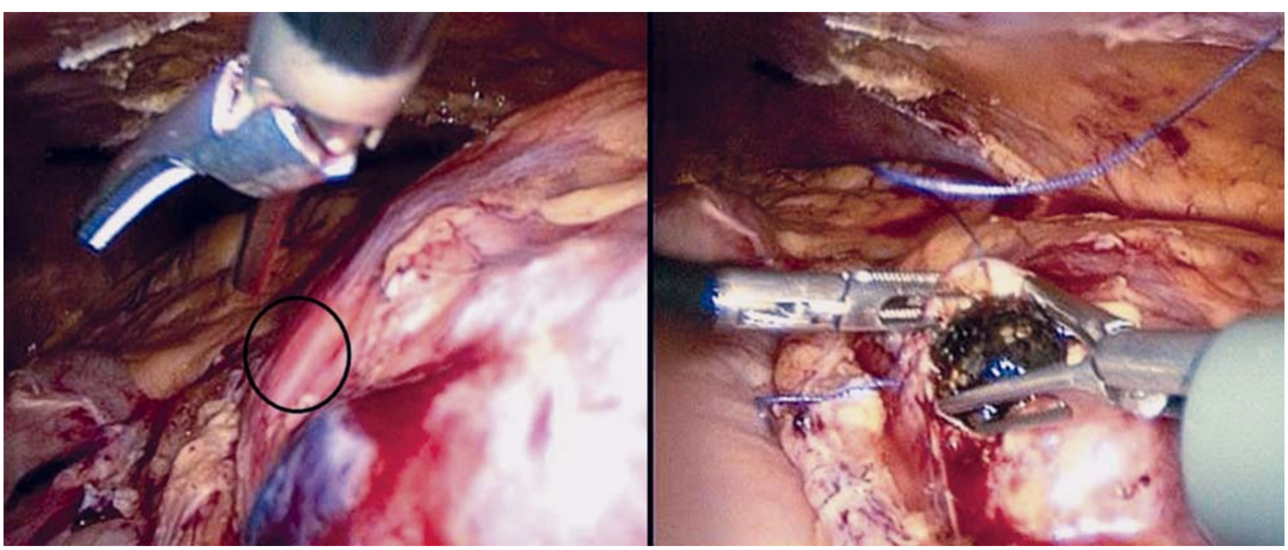

Figure 5 – Left: Endoscopic light transilluminates the location of an obstructed upper pole calyx (area inside the circle). Right: The kidney is incised over the lighted parenchyma and the stone removed laparoscopically.

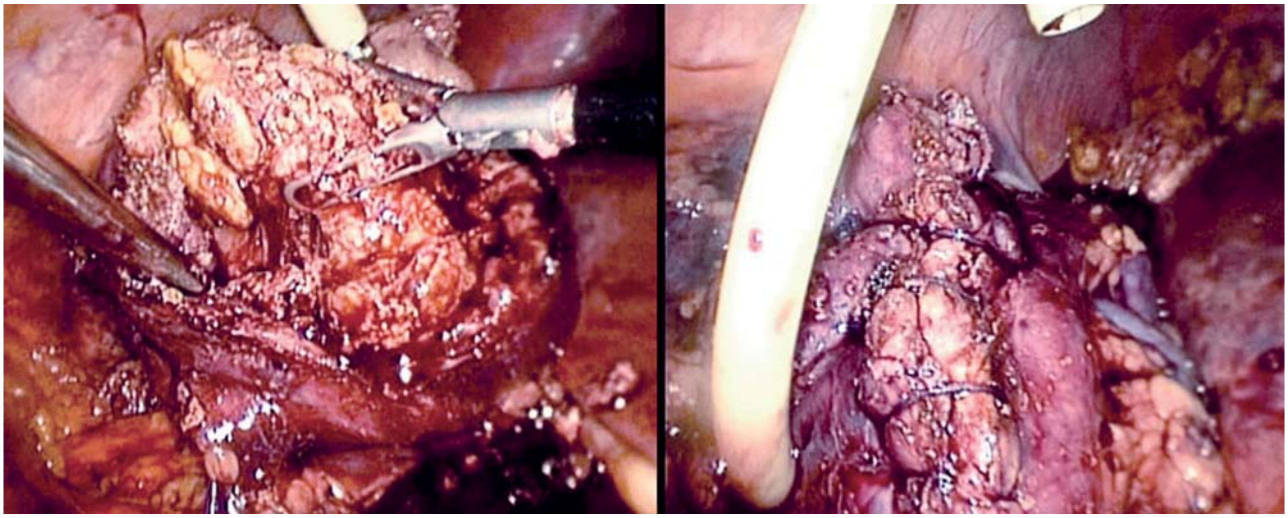

***Figure 6** – Left: Laparoscopic anatrophic nephrolithotomy, stone extraction. Right: One layer LapraTy™ assisted suturing of the kidney.*

and collecting system in a "no-knot" technique with the aid of Lapra-Ty clips (Ethicon-Johnsons & Johnsons), Figure-6.

RESULTS

Mean age at surgery was 36 years (range 18-56), ASA score 2 (range 1-2), and average number of stones removed was 12 (range 3 to 214). Laparoscopic pyeloplasty combined with pyelolithotomy and flexible nephroscopy was performed in ten patients, laparoscopic pyeloplasty with pyelolithotomy and endoscopic-assisted nephrolithotomy was performed in two; and laparoscopic anatrophic nephrolithotomy was performed in one patient (Table-2).

A double J stent and percutaneous drain was left postoperatively in all patients. Additionally, a nephrostomy drain using a 16 Fr Foley catheter was placed in two patients. All the procedures were completed laparoscopically with no conversions to open surgery. Intraoperative complications included two patients with lost stones in the abdomen diagnosed during follow up (Figure-7) and variable degrees of irrigation fluid accumulation secondary to nephroscopy in several others. One patient had a postoperative urinary leak in the context of an indwelling double J stent, which was not replaced at the time of surgery,

***Table 2** – Procedures performed and their indication.*

Procedure	Indication
1. LP combined with LPL and flexible nephroscopy	Patients with UPJO and associated pelvic and calyceal stones
2. LP combined with LPL and endoscopic-assisted LNL	Patients with UPJO and stones in an obstructed hydrocalyx or calyceal diverticulum
3. Laparoscopic anatrophic nephrolithotomy	Patient with double collecting system and complete staghorn of the lower moiety

LP = laparoscopic pyeloplasty; LPL = laparoscopic pyelolithotomy; UPJO = ureteropelvic junction obstruction; LNL = laparoscopic nephrolithotomy.

***Figure** 7 – Lost stones in the abdomen incidentally discovered during follow-up.*

and most probably chronically obstructed. Leakage was discovered during early postoperative period as urinary extravasation through the percutaneous drain. Cystoscopic replacement of the double J stent effectively treated the complication and the patient was discharged during the following days without evidence of further leakage.

Stone free status was obtained in ten patients (77%), and the remaining three were rendered stone free after one ancillary procedure (shockwave lithotripsy - SWL) in two patients and retrograde nephroscopy in another).

In all twelve patients with UPJ obstruction the pyeloplasty was considered successful according to clinical (disappearance of pain) and diuretic renal scan parameters. The mean washout half-life time in the diuretic renal scan improved from 43 to 22 minutes.

Warm ischemia time for laparoscopic anatrophic nephrolithotomy was 43 minutes; the patient was rendered stone free and renal function remained within preoperative values.

COMMENTS

Endourology has revolutionized the treatment of urinary stones. Notwithstanding, underlying anatomic anomalies, extremely large stone burdens or a combination of them can significantly decrease the success rate of endourological procedures (3,4). The surgical approach in these special cases should efficiently address the large stone burden and associated malformations in a single procedure. Although open surgery is an alternative, laparoscopic surgery might be a feasible option additionally conferring the advantages of minimally invasive surgery.

Micali et al. reported 17 patients who underwent laparoscopic stone extraction, including 11 with renal calculi and 9 with associated anomalies (UPJ obstruction) with stone size up to 6 cm; fifteen patients were eventually rendered stone free and one patient had a postoperative urinoma. These authors concluded that indications for laparoscopy included stones associated with anatomical abnormalities requiring reconstruction and calculi for which endourological procedures had failed (5). Ramakumar et al. reported 90% three month stone-free rate in 19 patients who underwent laparoscopic pyelolithotomy and pyeloplasty (6). Similar results were recently reported by Srivastava et al. (7) and Stein et al. (8) with 75 and 80% stone-free rates respectively.

Nambirajan et al. reported their experience with eighteen patients who underwent different laparoscopic procedures with concomitant stone removal, including pyeloplasties, partial nephrectomies, and calyceal ablations. Stone-free status was achieved in 93% of cases. The authors concluded that laparoscopy is effective for complex renal stones and that the need for open surgery should be rare in the future (9). Meria et al. compared laparoscopic pyelolithotomy to percutaneous nephrolithotomy (PNL) in 32 patients with pelvic stones without underlying malformations. Stone free rates were not significantly different (88 vs. 82%). However, the laparoscopic group had higher operative time, urological complications (12% urine leak), and conversion to open surgery was required in two patients. They concluded that indications for each technique must be determined although PNL remains the gold standard for large pelvic stones (10). It is our belief and current practice that SWL, retrograde and percutaneous techniques are the first approaches to treat kidney stones due to their excellent results and minimal morbidity. The role of laparoscopy is not to replace any of these options, but to compliment them in situations where decreased success or increased morbidity is expected, specially as regards large stone burdens coexisting with underlying malformations. As showed in our series and as reported by other authors (11,12), laparoscopic and endourological techniques can be successfully combined in the same procedure to improve the stone free rate and simultaneously resolve synchronous anomalies.

Tunc et al. published a study on 150 patients with stones in anomalous kidneys treated with SWL, including 57 duplex, 45 horseshoes, 30 malrotated, 14 pelvic, and 4 crossed ectopic. The overall stone-free rate was 68%, with the worst results obtained in crossed ectopic kidneys with stone clearance of only 25% (13). Pure percutaneous approach has also been reported in anomalous kidneys. Although highly effective with an overall stone-free rate of 83%, the anterior displacement of the collecting system together with an unpredictable vascular supply and interposition of bowel between the kidney and the abdominal wall makes the procedure technically demanding. Moreover, it requires a highly precise imaging system (i.e. CT guided) to minimize risk of visceral damage during kidney puncture and tract creation (14). Pure endoscopic management has also been accomplished for anomalous kidneys. Weizer et al. reported a 75% stone-free rate (15), meanwhile Braz et al. reported an 81% stone-free rate at three months, however 62% required ancillary treatments (16). Due to urinary stasis, these patients suffer from poor spontaneous stone passage, with persistence or growth of residual fragments in 60% of cases.

Laparoscopic techniques seem especially useful for stones located in anomalous kidneys. Our overall stone-free rate was 77% (10/13), and reached a 100% after one ancillary treatment (i.e. SWL or nephroscopy). Additionally, anomalies to be addressed (i.e. UPJ obstruction) were successfully repaired with optimal functional outcome.

There are several operative pitfalls that need special consideration when combining laparoscopy with endourological procedures. The operating room and the space around the operating table become limited when the laparoscopic and endourological towers need to be brought to work simultaneously. The laser cart and endourological instrumentation table pose additional ergonomic problems. One serious limitation is the difficulty to obtain fluoroscopic images during stone removal. Introduction of a C arm becomes a challenge in the described set-up and even if possible the images obtained in the insufflated abdomen of a patient in lateral decubitus are far from informative. Deflating the abdomen may improve the imaging but is unpractical and time consuming, and even after this, images are of poor quality due to patient position and free fluid in the abdomen, thus seriously limiting the ability to identify small residual stones.

Irrigating fluid that flows freely into the abdomen during the nephroscopy is of some concern and might be a limiting factor. Although some of it can be suctioned, still large quantities of fluid accumulate and occupy the space of the pneumoperitoneum. As fluid accumulates between bowel loops it cannot be directly aspirated. We overcame this difficulty by placing the patient in a “head down” position for two minutes, allowing the fluid to accumulate under the diaphragm where it becomes easily aspirated with the laparoscopic suction.

Identifying stones inside obstructed calyces can become a real challenge. Intraoperative ultrasound can be useful in these situations (9) however; it poses additional restrictions to the already cumbersome operative scenario. We found a solution relying on “cut for the light” technique, where the light of the endoscope marks the stone containing calyx and the location for the parenchymal incision. In the two cases performed, the light of the endoscope precisely delineated the place for the nephrotomy (Figure-5).

Kaouk et al. created a porcine model to address the feasibility of laparoscopic anatrophic nephrolithotomy (17), Deger et al. reported the first case in humans (18), and recently Simforoosh et al. (19) reported their series of five patients, with 3/5 being rendered stone-free. Interestingly, no postoperative urinary extravasation occurred albeit no internal stent was placed. We performed a laparoscopic anatrophic nephrolithotomy in a young patient with a duplex system and a complete staghorn of the lower moiety with optimal results and no perioperative complications. The kidney was repaired with one running suture including parenchyma and collecting system with no postoperative urinary extravasation.

An interesting aspect of laparoscopic pyelolithotomy concerns stones lost in the abdomen. It is not infrequent during retrieval of multiple small stones to have them fall out of the renal pelvis or the endobag, and locating them in the abdomen is challenging and time consuming. There is no report in the urological literature regarding this issue; however there are well described complications of lost stones in the abdomen after laparoscopic cholecystectomy. They include intraperitoneal and abdominal wall abscess, fistula, and prolonged fever (20). Regarding the infectious status of struvite staghorn stones, lost stones should remain of concern. However, two patients in our series had lost stones in the abdomen and after completing more than two years of follow-up, they remain completely asymptomatic.

We are aware of the limitations of this paper, which consist of a small, retrospective series of patients. However, considering the limited data published up to date we believe our experience contributes to the developing of this novel and poorly studied approach.

CONCLUSIONS

Although classical endourological procedures should remain as the gold standard for the great majority of renal stones, however patients with large stone burdens and underlying malformations might benefit from a combined laparoscopic and endourological one procedure solution that deals with complex stone disease and repairs associated anomalies.

CONFLICT OF INTEREST

None declared.

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EDITORIAL COMMENT

Authors present interesting series of patients with urinary stone disease managed mainly by laparoscopic method. The presented cases have some kind of anomaly necessitating laparoscopic approach rather than using routine endourological procedures like percutaneous nephrostolithotomy or urethroscopic means.

Laparoscopy is gaining more popularity in managing urinary stone disease (1-3). This is especially true when associated anomalies like ureteropelvic junction obstruction, or fusion anomalies exists (4).

Even though results of laparoscopic approach in managing stone disease in the present series and other reported series seems satisfactory (1-5), longer follow-up and more cases are necessary to better elucidate the exact role of laparoscopy in today's management of stone disease.

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EDITORIAL COMMENT

Laparoscopy is an established modality in management of renal stones in selected situations. On most occasions, laparoscopy is nephron sparing - namely - pyelolithotomy as compared with percutaneous nephrostolithotomy (PCNL).

The authors have successfully used laparoscopy combined with endourological procedures in anomalous kidneys, mainly ureteropelvic junction obstruction. This is a retrospective study. Larger and prospective studies will help in developing concrete guidelines.

It is to be noted that a renal angiogram or CT angiogram is a complimentary investigation in planning reconstructive laparoscopic surgery in anomalous kidneys.

The authors have not done an infundibuloplasty in cases of infundibular stenosis with calyceal diverticulum and; the collecting system was not closed separately in patients with staghorn calculus where an anatrophic pyelolithotomy was done. It would be interesting to see the configuration of the collecting system using a CT scan during follow-up.

In most centers, pyeloplasty is done with interrupted sutures. The authors have used running sutures for the anterior and posterior walls.

Meria et al. had shown similar results with different modalities (PCNL and laparoscopy) in management of stone disease in non-anomalous kidneys; however the complication rate in was higher in laparoscopy compared to ESWL and PCNL. Hence, they concluded that ESWL or PCNL should be the first option in non-anomalous kidneys.

Practical problems of C arm usage; ultrasound usage and free flow of irrigating fluid into the peritoneal cavity with laparoscopy are problems to be looked into.

Combining laparoscopy with PCNL and pure endoscopy gives a better result in stone disease.

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