Difficulties in Laparoscopic Surgery for Urinary Stones

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Introduction

Stone disease has been a great challenge for surgeons through history and in fact one of the first surgeries performed in human has been for stone. For centuries stone disease has been a common health problem and traditional open surgery has been practiced to manage problems caused for human by urinary stones [1]. Today, stone disease is still common, but the pattern of practice in stone management has been revolutionized in the last decades. In the era of minimally invasive surgery, open surgery for stone disease is obsolete and almost abandoned [2]. The biggest blow to open surgery came about when extracorporeal shock wave lithotripsy (SWL) was applied successfully by Chaussey in Berlin [3]. While, percutaneous nephrolithotomy (PCNL) and ureteroscopic lithotripsy were another great steps forward and today have major roles in managing large renal and ureteral stone disease in most of the continents of the world.

The technology of pneumolithotripsy and laser lithotripsy is another important achievement in dealing with stone disease during PCNL and ureteroscopic lithotripsy, which is used commonly in many countries due to its effectiveness and especially cost effectiveness. Introducing flexible instruments facilitates navigation through the collecting system. Disposable flexible endoscopes seem to be promising alternative to costly fiberoptic ones to solve their cost and maintenance problems.

All above measures which are called today "ENDOUROLOGY" has made us to put knife aside in almost all cases of stone disease.

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In the era of minimally invasive endoscopic procedures and shock wave lithotripsy (SWL), laparoscopy has limited role in armamentarium of urologist for surgical stone management [4]. However, in case of large stones, single or combined endourologic procedures may not be cost effective than single one session approach for complete stone removal [5]. Therefore, OSS including open ureterolithotomy, pyelolithotomy and nephrolithotomy has still had its role in many centers. Laparoscopic stone removal is a valuable option in these situations which offers a less morbid modality for removing large stones in the urinary tract.

In this chapter we have focused on the potential difficulties and complications that may occur during laparoscopic stone surgery and the approaches to deal with them have been discussed.

Laparoscopic Ureterolithotomy (L.U): Difficulties and Their Management

Laparoscopic ureterolithotomy (LU) is an alternative option for removing larger than 15 mm impacted ureteric stone [6, 7] or may be used as a salvage procedure in failures of SWL and/or ureteroscopic lithotripsy [8].This technique usually results in complete stone removal through a single minimally invasive surgery in a reasonable operative time and short hospital stay [9]. Thus the indications for laparoscopic ureterolithotomy in the era of modern endourology include stones which cannot be accessed ureteroscopically or cannot be fragmented. (Fig. 17.1)

LU can be accomplished through transperitoneal (TP) or retroperitoneal (RP) route. Although the preferred approach is mainly defined by surgeon's preference and experience, we think that TP approach might be the preferred approach specially for beginning or average laparoscopic surgeon. Since TP approach provides a larger working space with familiar anatomic landmarks compared with RP route. Moreover, difficulties and complications might be better handled [10]. In the absence of dense retroperitoneal fibrosis laparoscopic ureterolithitomy is almost easy procedure especially for beginners. Laparoscopic ureterolithotomy for distal ureteral stones, especially those lodged behind the bladder and very close to ureterovesical junction, is more difficult and needs more expertise.

Stone Migration during LU

The ideal case for LU is a large impacted ureteral stone. However, as in open ureterolithotomy, there is always a potential risk of upward stone migration during the procedure. To decrease the chance of stone migration to the kidney, ureteric dissection should be accomplished as gently as possible from proximal to distal direction. Once the dilated ureter above the site of impacted stone identified, placing a laparoscopic Babcock prevents stone migration during further ureter dissection. Placing patient in head up position, making patient well hydrate and intravenous infusion of

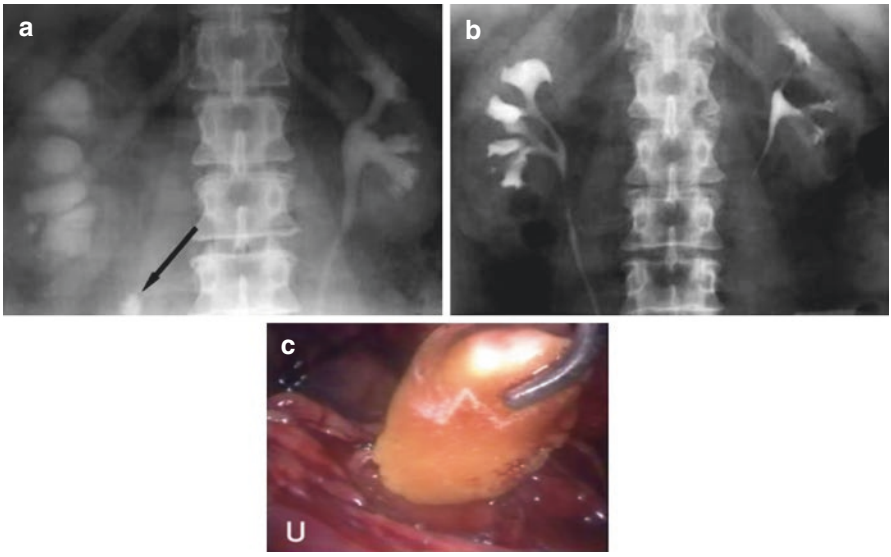

Fig. 17.1 Preoperative (**a**) and postoperative (**b**) IVU following laparoscopic ureterolithotomy (**c**). Significant relief of obstruction is noted (*Arrow* shows the proximal ureteral stone, *U* ureter)

0.5 mg/kg frusemide may help to prevent stone migration. In case of stone migration, one should open the ureter at the site of stone impaction and by passing the rigid or flexible ureteroscope through lower abdominal 5-mm laparoscopic port, ureteroscopy could be easily performed up to the renal calices. Then, the migrated stone could be pushed back to the site of ureteric incision by basketing or milking the ureter by laparoscopic Babcock.

Difficulties in Stone Localization During LU

Sometimes, after dissecting the ureter, it is difficult to localize the site of stone. This may especially occur in obese patients and those with dense, fibrotic adhesions around the ureter due to chronic inflammation or multiple sessions of SWL. Intermittent pressing the dilated proximal ureter in proximal to distal direction by laparoscopic Babcock may help to sense the site of impacted stone. Difficulty in localizing the stone due to severe peri-ureteric fibrosis can be overcome by the use of fluoroscopy or intraoperative laparoscopic ultrasonography. If still the stone could not be localized, one can fix the problem by proximal and distal ureteroscopy after opening the ureter at the site of its maximal dilation and passing the rigid or flexible ureteroscope to the ureterotomy via lower or upper abdominal trocars. After finding stone, it can be removed through the ureteral incision by milking, basketing or it might be fragmented in-situ with pneumatic or laser lithotripsy.

Stone Adhering to the Mucosa

Sometimes, after ureteral incision, the stone could not be easily delivered because of its adherence to the ureteral mucosa. This is especially true in long standing, large impacted stones and those with multiple sessions of SWL. After proximal extension of the ureteral incision over the dilated proximal ureter, with the aid of laparoscopic hook one can separate the "head" of stone from ureter. Then, the rest of stone can be easily released from ureteral mucosa using laparoscopic Babcock. Levering the stone out of the ureter prevents its breakage and subsequent problems with small pieces. It has been recommended that direct stone grasping with laparoscopic grasper should be avoided especially when the stone is not hard enough. Because grasping the stone can break the stone with possibility of migration [11].

Lost Stone

Sometimes, after stone extraction, the stone might be lost before its extraction from abdomen. It is recommended that before incising the ureter, the surgeon places the endobag or its alternate in the abdomen to put the stone into the bag just after its removal. Sometimes, the stone is already fragmented (perhaps due to previous SWL-effect) or it might be fragmented by the force of graspers at time of extraction. Having the bag near to the field lets the surgeon to collect the fragments without losing them.

Anyhow, in case of lost stone, usually the stone stays medial to the ureter over the reflected colon. Changing the camera port may help to find the lost stone.

Stenting and Suturing

Classically, both ureteral stenting and suturing have been recommended. Laparoscopic antegrade ureteral stenting is feasible by placing the double j or feeding tube in laparoscopic suction and guide it to the ureteral incision. However there is evidence that ureteral stenting during LU could be obviated safely. Demirci and his colleagues have shown the safety of leaving the sutured ureterotomy without stenting [12]. Similar findings have been demonstrated by others [8, 9]. Goel and Hemal recommended stenting only in the setting of renal dysfunction and/or stone impaction [13].

Suturing of the ureterotomy incision is usually a simple task. Laparoscopic magnification allows clear visualization of mucosal apposition. Sometimes, suturing is not possible due to severe inflammation and fragility of the tissue. Fixing a stent in the ureter and leaving the unsutured ureteral incision with an external draining catheter could be planned safely in these circumstances [5, 8, 9].

Ureteral Stricture

The incidence of ureteral stricture following LU has been reported between 2.5–20% [14, 15]. Various contributing factors may have a role for development of ureteral stenosis. Nouira and his coworkers have recommended that adhering to the

principles of ureterotomy closure during open surgery (i.e. loose sutures in order to just approximate the ureteral edges) may reduce the chance of ureteral stricture following LU [14]. They also believe that using laparoscopic cold knife instead of electrical hook is a more suitable task. However, we as well as many authors believe that the use of cutting-mode electrical hook is much easier and more popular [5, 9]. To decrease the rate of stricture we suggest that the cutting- electrical hook should be applied only on the dilated ureter proximal to the stone and the extension of the hook-incision should be done by laparoscopic scissor.

Laparoscopic Pyelolithotomy (L.P): Difficulties and Their Management

Compared with percutaneous nephrolithotomy (PCNL), laparoscopic removal of renal pelvic stone has limited role. And its indications have not been clearly defined. There are a few comparative studies between PCNL and laparoscopic pyelolithotomy (LP) in the literature [16, 17]. In a prospective cohort trial, the stone free rate was significantly higher for LP in comparison with PCNL in patients with a solitary renal pelvis stone larger than 30 mm (100% versus 76.7%). Interestingly, overall treatment cost was determined by the need for ancillary procedures; both were higher in PCNL group [18]. Through a randomized clinical trial, the stones free rates were shown similar after LP versus PCNL in patients with a renal pelvis stone ≥2 cm. The need for blood transfusion and mean blood loss were lower in LP and interestingly, the recovery of GFR three months after the operation was quicker in LP group; all indicative of a lesser cortical injury during LP [19]. In situations of failed percutaneous access due to technical reasons, a laparoscopic approach in selected cases may provide a similar success rates as open surgery. We think that LP could be reserved as an alternative approach in selected cases of large renal pelvis stones, stones resistant to fragmentation and in those with abnormal kidney anatomy. This technique allows en-block stone extraction in a minimally invasive milieu. The procedure is easier in patients with an extra renal pelvis. The efficacy of LP (Stone free rate: 84.6%) for removal of partial or complete staghorn stones have also been shown in small series [20]. Again en block removal of these large stones minimized the need for further ancillary procedures.

Dissecting the Renal Pelvis

Identification and dissection of proximal ureter is the initial step during LP. Dissection over proximal ureter usually guides the surgeon to the renal pelvis. Aggressive dissection over UPJ especially in the presence of inflammation may lead to UPJ avulsion. In case of avulsion, meticulous dissection and mobilization of renal pelvis may allow laparoscopic reanastomosis following stone removal via the pyelotomy incision (Fig. 17.2).

Renal pelvis should be released and dissected completely before pyelotomy. In patients with prior retroperitoneal surgery transperitoneal approach is recommended (Fig. 17.2).

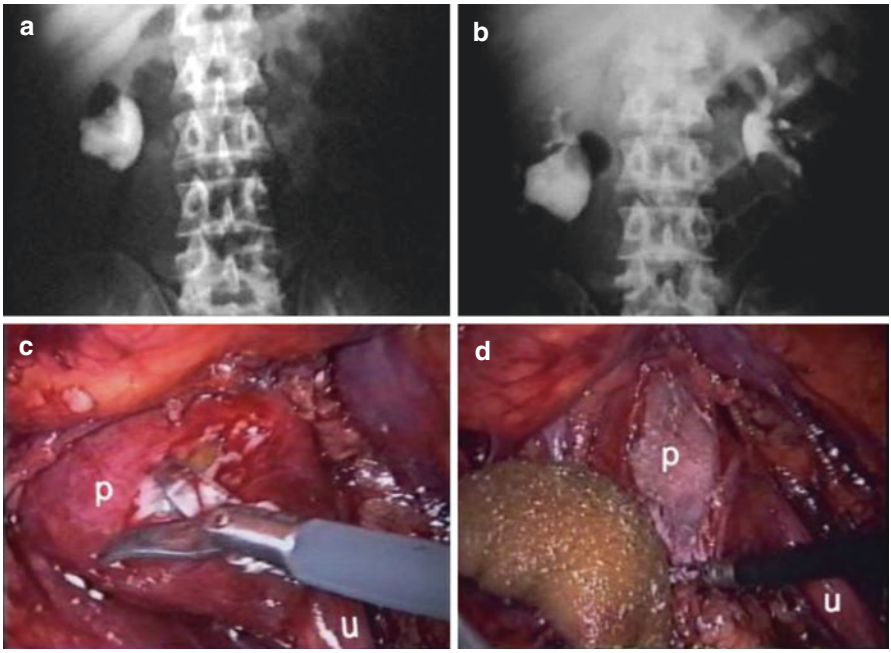

Fig. 17.2 Preoperative KUB (**a**) and IVU (**b**) of a patient with a large renal pelvis stone. Laparoscopic pelvic dissection and stone extraction have been carried out (**c, d**). (*U* ureter, *P* renal pelvis)

During LP, dissection should be done over the renal pelvis to prevent inadvertent injury to the branches of renal artery, renal vein and aberrant vessels. Peripelvic inflammation as well as a number of aberrant vessels may be found while dissecting the pelvis and this requires expertise in laparoscopic dissection. Conversion to open surgery may be required due to significant perinephric adhesions and resultant difficulty in dissection

Pyelotomy and Stone Removal

The pyelotomy incision can be made using a laparoscopic knife or more popularly, cutting-mode electrical hook. Incision may be longitudinal or transverse. Sometimes, especially in case of large impacted stone, it would be better to place two stay sutures at both ends of pyelotomy incision to prevent incision extension during stone removal. These sutures make pyelotomy closure easier. The pyelotomy could be well extended to the superior and inferior calyces or their infundibula. Gentle delivery of the "tail" of stone from UPJ together with rotating and twisting maneuvers help to extract large stones. This invariably led to delivering one end of the partial staghorn stone out first, allowing manipulation of the other end.

One of the major limitations of the laparoscopic approach is difficulty in retrieving the caliceal calculi.

In situations where the stone was too large for the port site, it could be placed in a laparoscopic sac and removed via the umbilical laparoscopic port site by extending the incision. Alternatively, it could be fragmented within the endobag and removed via a smaller incision.

Stone Migration

Stone migration during LP usually occurs in the presence of small renal pelvis stone causing severe hydronephrosis. If stone migrated to the kidney, guiding a flexible or rigid ureteroscope to the pyelotomy incision via lower abdominal laparoscopic port allows direct exploration of the calyces and stone removal under direct vision with a nitinol stone basket. Since the patient is in lateral decubitus position, the migrated stone often falls into the upper pole calyces. Micali et al., have also described removal of pelvic and caliceal calculi using the flexible cystoscope through the 10/12 mm laparoscopic port [21].

Pyelotomy Closure

Reconstructing the pyelotomy requires advanced laparoscopic skills for intracorporeal suturing. Sometimes, the edges of the incised renal pelvis are inflamed and fragile and suturing is not possible. Antegrade placement of a ureteral stent and applying two sutures at both ends of pyelotomy incision and tying them to each other usually fix the problem [22]; excessive manipulation in such situations may result in renal pelvis disruption.

Laparoscopic Nephrolithotomy

Staghorn renal stones are a challenging issue in urology. Even with the introduction of endourological methods, the management of staghorn renal stones remains challenging. Several series have considered open anatrophic nephrolithotomy for management of staghorn renal stones even in the era of endourology. Due to high incidence of recurrence of staghorn stones, particularly those associated with an infective process, the complete removal of the stone is the ultimate goal in their management, a result that might not be attained even after several sessions of PCNL and/or ESWL and/or retrograde intrarenal surgery [6, 23, 24].

Laparoscopic anatrophic nephrolithotomy (LAN) can be considered as an alternative for open surgery of staghorn renal stones. Since its introduction in 2008 [25, 26], several groups have shown the feasibility of this minimally invasive modality (Table 17.1). One session stone free rate was between 60 and 90.9% with mean warm ischemia time (WIT) of 20.8–32 and mean operative time of 139–192.3 min.

Table 17.1 Perioperative outcome of laparoscopic anatrophic nephrolithotomy series

Study	Sample size	Mean operative time (min)	WIT (min)	Mean stone size (mm)	Stone free rate (%)
Simforoosh, 2008 [26]	5	170	32	53	60
Zhou, 2011 [27]	11	139	31	52	90.9
Giedelman, 2012 [28]	8	142.5	20.8	53	62.5
Simforoosh, 2013 [29]	24	185	30.4	61.5	88
Aminsharifi, 2013 [30]	10	192	32.8	67.3	80
Aminsharifi, 2016 [31]	15	192.3	31.8	69.8	80

WIT warm ischemia time

LAN is a complex laparoscopic procedure requiring full laparoscopic experience. Large burden "en-blocked" complete or partial staghorn stones are appropriate candidate for LAN. Small burden stones and stones with many particles in different calyces are very difficult for LAN and may increase the WIT. Renal vascular anatomy, stone size and burden should assessed preoperatively by computerized tumographic angiography and intraoperative ultrasonography may be helpful for delineating the stone morphometry.

Surgical Technique

After complete dissection of both renal artery and vein, Gerota's fascia incised and the kidney fully mobilized within this fascia. Unless the renal parenchyma is atrophic the renal artery should be clamped temporarily by a bulldog clamp. Through an incision with sufficient length on the Brodel line, the collecting system sharply incised and the staghorn stone mobilized intrarenally, rotated and removed as completely as possible (Fig. 17.3). In order to decrease warm ischemia time, both of the collecting system and renal cortex could be closed with a single row of polyglactin 2-0 running sutures and the sutures would be buttressed by applying Hem-o-lok clips instead of tying knots. Intraoperative laparoscopic ultrasonography might be used to identify the site of thinnest parenchyma and detecting possible residual stones.

One of the major concerns regarding the LAN is the effect of warm ischemia on the renal function. In a series of 10 cases of complete staghorn stones managed with LAN, the renal function of the affected kidney was monitored 12 month after the surgery with Technetium-99 dimercaptosuccinic acid scintigraphy (99Tc-DMSA), mean renal function decreased significantly from 48.4% ± 8.83 to 41.4% ± 13.98 (−7% ± 6.53) [30]. In another prospective cohort trial, the outcome of PCNL versus LAN versus Open nephrolithotomy for management of complete staghorn stones were compared [31]. The stone free rate was significantly higher

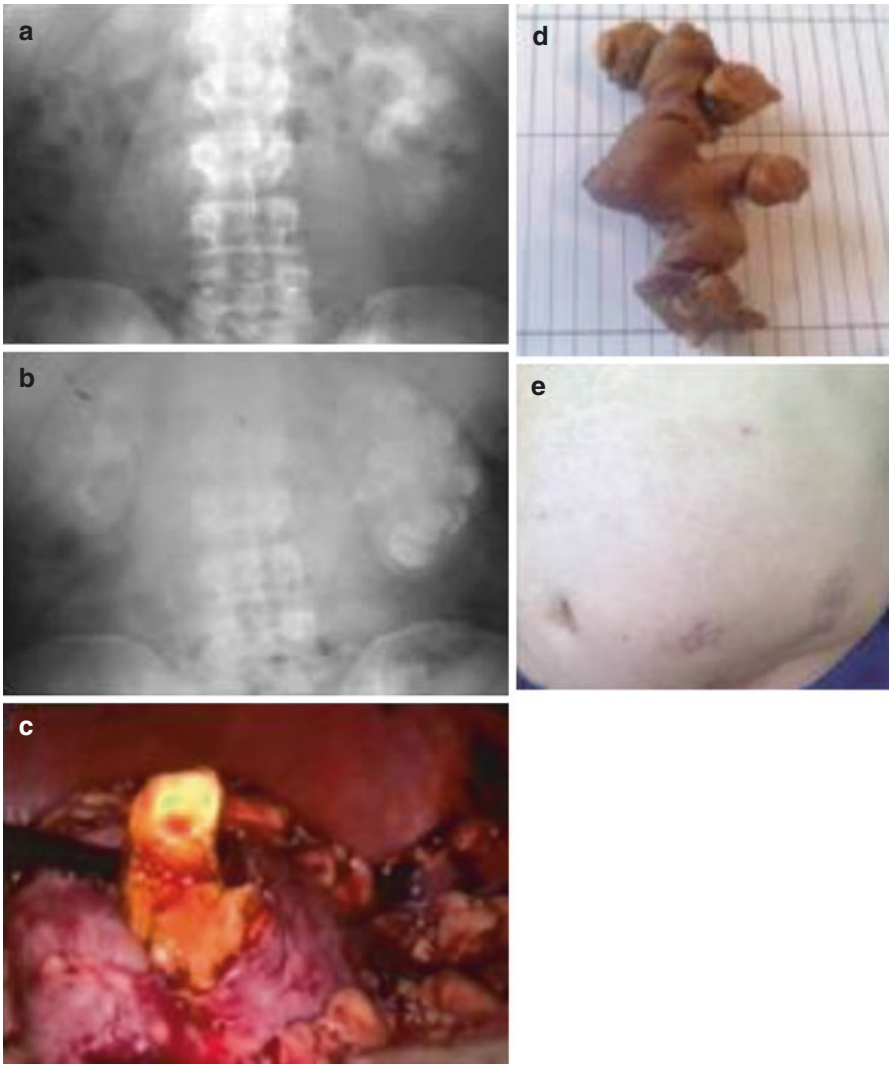

Fig. 17.3 Preoperative KUB (**a**) and IVU (**b**) of an obese patient with a large co mplete staghorn renal stone (**c**) extracted by laparoscopic anatrophic nephrolithotomy (**d**). Sites of trocars are shown (**e**) (From Simforoosh et al. [26] Reprinted with permission from Wiley-Blackwell)

after open surgery (92.8%) in comparison with LAN (80%) and PCNL (43.7%). Therefore, the need for ancillary procedure and in turn the overall treatment costs were the highest for PCNL and the least for open nephrolithotomy. In this trial, the renal function of the operated kidneys were monitored after a mean follow up period of 12 months. The more invasive the procedure is, the greater renal functional loss(−2.12% for PCNL versus −6.04% for LAN versus −8.66% for open nephrolithotomy).

Laparoscopic Management of Stone Disease in Anomalous Kidneys

Relative urinary stasis imposed by anomalies in the collecting system predisposes the kidney to urolithiasis and increase the risk of stone recurrence.

Ureteropelvic Junction Obstruction (UPJO) and Stone

There is a 70-fold increased risk of stone formation in patients with UPJO [32]. Since laparoscopy is becoming the standard of care in managing UPJO, when there is concomitant stone, it can be removed by laparoscopy during the procedure of pyeloplasty [32, 33]. Stone can be removed by laparoscopic instruments if it is located in the renal pelvis or at visible areas of the kidney. Furthermore, navigation within collecting system is possible using flexible or rigid endoscopes. After localizing the hidden stone, it could be managed with basketing and/or pneumatic or laser lithotripsy, under direct vision.

We have used rigid ureteroscope and pneumatic lithotriptor successfully during laparoscopy for management of stone in kidneys with UPJO. In case of failures, intraoperative ultrasound can also be used to localize the stone in the kidney. Sometimes, after stone localization with intraoperative ultrasonography, nephrotomy over the stone is necessary for en-block stone extraction. This is especially true when the stone is located in inaccessible calices in the hydronephrotic system. Nephrotomy can be done without hilar clamping since renal cortex is usually thin when it is associated with UPJO.

Horseshoe Kidney

Relative urinary stasis and abnormal anatomy of collecting system in those with horseshoe kidney put them at risk of urolithiasis with an incidence rate of 21–60%. Various single or combined endourologic procedures such as SWL and PCNL can provide up to 90% of stone free rate in these patients [34–36]. Laparosopic pyelolithotomy is an alternative option in patients with horseshoe kidney having large burden stone in the renal pelvis or isthmus. There are several advantages of laparoscopic approach in removing stone from horseshoe kidney. All of the procedure can be done under direct vision without any need of radiation exposure. There is no glomerular damage and less chance of hemorrhage. Stone can be removed in one piece especially if it is located in the renal pelvis (Fig. 17.4). When UPJO is associated with horseshoe kidney, pyeloplasty can also be performed simultaneously. During laparoscopy, care should be taken not to injure anomalous vascular supply to the horseshoe kidney.

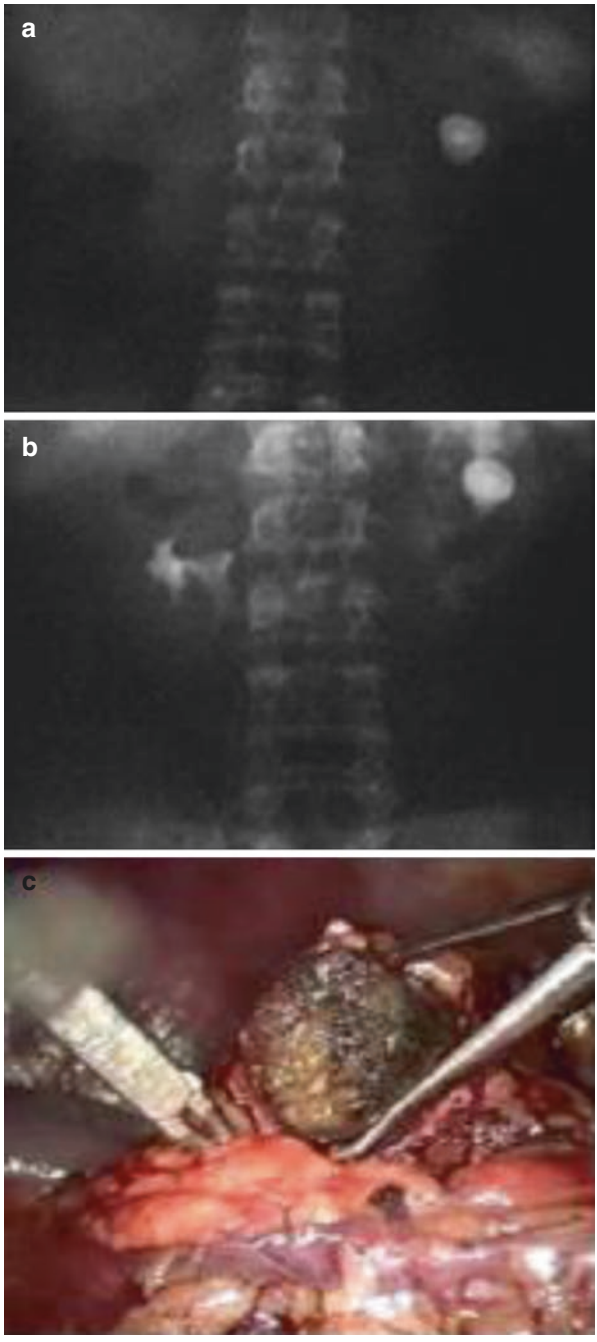

Fig. 17.4 Preoperative KUB (**a**) and IVU (**b**) of a patient with a large renal pelvis in his horseshoe kidney. The stone was removed by laparoscopic pyelolithotomy (**c**). The renal pelvis was easily accessed during laparoscopy due to its anterior position

Fig. 17.5 Preoperative KUB (*left*) and IVU (*right*) of a patient with an upper calyx stone in his ectopic kidney (indicated by *arrows*). The patient was successfully managed by laparoscopic-assisted PCNL

Cross-fused Kidney

We have successfully removed stone from a crossed fused ectopic kidney. It was very difficult to find a bare area of pelvis for pelviotomy due to abnormal vascular anatomy but with great care and patience this was possible and a large stone was extracted from the kidney en-blockly.

Pelvic Kidney

While laparoscopic assisted PCNL is standard of care for minimally invasive management of stone in pelvic kidney [37], large stones especially in the renal pelvis of pelvic kidney can be removed by laparoscopy. Since the kidney is located in a lower anatomic position in the abdomen, transperitoneal laparoscopy is the best alternative to open surgery in these circumstances (Fig. 17.5).

The authors successfully removed the kidney stone from renal pelvis of a pelvic kidney in our early experiences but unfortunately the stone was dropped and lost during the surgery. We did not convert the procedure to open surgery. Post operative imaging revealed the lost stone behind the spleen. Stone did not cause any clinical problem during follow up and was left intact.

Retrocaval Ureter

If there is stone in the kidney with retrocaval ureter, laparoscopic stone removed can be performed directly or by using other endourologic means like flexible or rigid ureteroscopy or percutanous approach. We have reported six cases of retrocaval ureter, one of them was associated with stone. The stone was removed with laparoscopic grasping forceps in one piece [38].

Summary

Although laparoscopic stone surgery has limited role for management of urolithiasis, it could be offered as a proper alternative to open stone surgery. Proper case selection for laparoscopic ureterolithotomy, pyelolithotomy and especially laparoscopic anatrophic nephrolithotomy is the key for preventing complications during the procedure. However, most of the difficulties during these techniques could be managed without any need to open conversion.

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