Difficulties in Laparoscopic Nephroureterectomy

10

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Introduction

Upper urinary tract urothelial carcinoma (UUT-UC) is a relatively uncommon disease and accounts for about 5% of all urothelial tumors and 5–10% of all renal tumors, respectively [1]. UUT-UC is located more commonly in the renal pelvis than in the ureter with a ratio of 3:1 [1, 2] and occurs more frequently in men with a male-to female ratio of 3:2 for tumors in the renal pelvis and 2:1 for a ureteral location [3]. The incidence of bilateral UUT-UC ranges from 2 to 8% [1, 4]. Although development of UUT-UC after primary diagnosis of bladder cancer is a rare event, occurring in only 2–4% of patients with bladder cancer [5], the development of secondary bladder cancer after primary UUT-UC is about tenfold more frequent with a risk of 20–50% [2, 6]. Open radical nephroureterectomy (O-RNU) has been the gold standard for the treatment of UUT-UC for decades. Conventional open complete nephroureterectomy with excision of the ipsilateral orifice and a bladder cuff requires one or two long incisions associated with respective morbidity. Therefore, based on the first report of McDonald in 1952, several authors have tried to minimize the access trauma with the use of an endoscopic transurethral detachment technique of the distal ureter [4]. With the advances in laparoscopic techniques

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and endourologic procedures, this concept has been increasingly challenged. In 1991, Clayman first described the technique of laparoscopic nephroureterectomy, which was soon replicated by various authors worldwide [7]. Compared with open surgery, advantages of laparoscopy have been reported as shorter hospital stay, decreased postoperative pain, and earlier return to normal activities [8, 9].

As with open surgery, the laparoscopic approach can be transperitoneal or retroperitoneal. Initially laparoscopic procedures were hampered by long operative times, which led to the development of hand-assisted laparoscopic nephroureterectomy (HAL-RNU) to decrease operating times [10]. With increasing experience, however, operating times have declined and are usually not longer than those for open surgery [11]. One technical point of concern has been the management of the distal ureter and the bladder cuff. A variety of options have been reported: the pluck technique with transurethral resection of the ureteral orifice originally described to facilitate open surgery and spare a second incision [12], cystoscopic circumferential incision of the ureteral orifice [13, 14], transvesical laparoscopy with dissection of the orifice [15], an endoscopic GIA stapler [16], or an open approach as in O-RNU to retrieve the specimen and gain access to the distal ureter and bladder wall [17].

The advantages of laparoscopic nephrectomy for benign disease have been well proven in several comparative studies, revealing a significant reduction of postoperative morbidity. [18] However, in case of oncological indications, such advantages must be balanced against possible risks, such as port site metastases or local recurrences [19, 20]. Moreover, long-term follow-up is necessary to evaluate the oncological outcome in comparison to open and endourological techniques [21]. As it has been more than 10 years since the first description of laparoscopic nephroureterectomy, it seems appropriate to analyze the current status of this technique in the management of upper tract transitional cell carcinoma [22].

This chapter attempts to place the status of laparoscopic nephroureterectomy in perspective. Laparoscopic techniques, including patient preparation, positioning, technical caveats, and intraoperative difficulties are presented.

Indications

The most common indication for nephroureterectomy (NU) is transitional cell carcinoma (TCC) of the ureter or renal collecting system. The procedure is less commonly performed for benign conditions associated with nonfunctioning kidneys in which it is desirable to remove the kidney and ureter. If a patient is at risk for renal failure following removal of a renal unit, then a renal-sparing approach should be considered. The only absolute contraindication to the procedure is an uncorrected bleeding diathesis. Relative contraindications are similar to those of patients undergoing laparoscopic nephrectomy and include kidneys with chronic inflammation (i.e., concomitant xanthogranulomatous pyelonephritis, tuberculosis) in which the risks of complications and conversion to an open procedure are extremely high [23].

Preoperative Evaluation and Preparation

When evaluating for TCC of the upper tracts, the diagnosis should be confirmed by characteristic radiologic appearance and upper tract cytologic evaluation or ureteroscopic evaluation with biopsy of the lesion. Multiplicity of tumors should be excluded with cystoscopy and radiographic evaluation of the contralateral collecting system. In-office flexible cystoscopy is performed to rule out concurrent bladder tumors and assess bladder capacity. Presence of active bladder tumor diathesis is a contraindication of this procedure. Diminished bladder capacity (less than 200 mL) increases the technical complexity of this technique because of the minimal working space within the bladder [16].

Staging procedures are particularly important with high-grade lesions and should include chest radiography, liver function tests, computerized tomography (CT) scan of the abdomen, and bone scan depending on the clinical stage of the lesion. If there is a risk of renal failure following removal of a renal unit, a nephrology evaluation should be undertaken preoperatively to aid with postoperative management and possible dialysis. A gentle mechanical bowel preparation with clear liquids and a mild laxative administered 1 day preoperatively will help prevent bowel distension. The patient should be typed and cross-matched, and is given prophylactic antibiotics [24].

Surgical Techniques

As in open surgery, there are several technical modifications of the procedure with respect to nephrectomy as well as regarding the method of ureterectomy. Laparoscopic nephroureterectomy can be performed via transperitoneal or retroperitoneal access, in a pure laparoscopic, hand-assisted, or robot-assisted laparoscopic technique.

Patient Positioning

For the first step of securing the distal ureter, the patient is in a dorsal lithotomy position. For the second step of the nephroureterectomy itself, the patient is placed in a lateral decubitus position. All bony prominences must be padded. The downside axilla should be checked to ensure it is free of pressure. The upside leg should be elevated on one or two pillows until it is aligned smoothly with the upside flank. The patient is positioned on a radiolucent table top that has wedge-shaped, padded bolsters that secure the patient in position while offering excellent padding (Orthopedic Systems Inc., Union City, CA). The patient is strapped to the operating room table at three points: subaxillary, lower hip, and knee level. Egg crate padding is positioned beneath each strap where it crosses the body.

Patient Preparation

Before beginning laparoscopy, a nasogastric tube and a Foley catheter are always inserted. In men, gauze can be used to wrap the scrotum to prevent CO_2 from filling and distending the scrotum. Pneumatic stockings are placed on both legs. On call to the operating room, a single dose of a second-generation cephalosporin is given.

Preparation of the Bladder Cuff and Intramural Ureter

There are many alternatives for dealing with the distal ureter and ensuring a bladder cuff. Each has its own advantages and disadvantages.

Ureteral Stent Placement Without Ureteral Unroofing

External ureteral stent placement (e.g., 7.1-F pigtail catheter) is done to facilitate ureteral identification and dissection. The bladder cuff and distal ureter are taken through an open lower abdominal incision at the end of the procedure.

Ureteral Stent Placement with Ureteral Unroofing [25]

Using the flexible cystoscope and under fluoroscopic guidance, a 0.035-in. Bentson guidewire is passed to the renal pelvis. The flexible cystoscope is withdrawn, and a 7-F ureteral dilating balloon (5-mm diameter, 10-cm length) catheter is inserted over the guidewire. The balloon is inflated to less than 1 atm of pressure with dilute contrast material mixed with indigo carmine to enhance visualization of the inflated balloon. A 24-F resectoscope equipped with an Orandi electrosurgical knife (Cirion-A, Santa Barbara, CA) is passed. Beginning at the presumed level of the luminal side of the ureterovesical junction, the ureteral tunnel and ureteral orifice are electrosurgically incised anteriorly over the balloon, exposing the underlying surface of the inflated balloon. The Orandi knife then is exchanged for a roller ball electrode and the edges of the incision are fulgurated to maintain hemostasis. The dilating balloon catheter is deflated and the roller electrode is used to fulgurate the posterior luminal portion of the now unroofed ureteral tunnel completely. The resectoscope then is removed. Next, the dilating balloon catheter is removed, and a 7-F, 11.5-mm occlusion balloon catheter is inserted under fluoroscopic guidance over the Bentson guidewire and is advanced into the renal pelvis. The balloon is inflated with 1 cc of dilute contrast medium and is positioned at the ureteropelvic junction. The Bentson guidewire is replaced with a 0.035-in. Amplatz super-stiff guidewire. A sidearm adapter passed over the super-stiff guidewire, is affixed to the butt end of the occlusion balloon catheter, and is placed for drainage. A 16-F Foley urethral catheter is inserted alongside the 7-F occlusion balloon catheter. This procedure promotes ureteral identification and dissection in preparation for eventual stapling of the bladder cuff, and limits any leakage of urine or spillage of TCC cells into the extraperitoneal space [25].

Ureteral Orifice or Tunnel Resection into Fat: The Pluck Procedure

With the patient in a supine position, using a standard resectoscope, the ureteral orifice, tunnel, and intramural ureter are resected transurethrally until the perivesical fat is seen. This procedure is quick and facilitates the laparoscopic nephroureterectomy (LNU) procedure because no ureteral catheter is placed; instead of dissecting the distal ureter, the surgeon can merely *pluck* the ureter cephalad from out of the pelvis during the laparoscopic nephrectomy. The only drawback to this approach is the concern over the leakage of malignant, cell-laden urine into the retroperitoneum until the ureter is occluded laparoscopically [26]. Instances of seeding after a pluck procedure have been reported by several urologists [27, 28]. In an recent study, transurethral resection of the ureteral orifice during LNU achieves acceptable long-term oncologic outcomes while minimizing perioperative morbidity and in-patient stay. This represents the largest single-center study of this technique to date [29].

Transvesical Laparoscopic Ureteral Dissection [16]

Under cystoscopic control, two 5-mm balloon tipped trocars are inserted suprapubically into the bladder. An endoloop tie is inserted through the ipsilateral suprapubic port and positioned around the targeted ureteral orifice. A ureteral catheter is cystoscopically passed through the endoloop into the ureteral orifice up to the renal pelvis (Fig. 10.1a). The targeted ureteral orifice is grasped with a grasper inserted through the contralateral suprapubic port and retracted anteriorly. This procedure tents up the ipsilateral hemitrig-one, thus elevating the bladder base (Fig. 10.1b). A 24-Fr resectoscope fitted with a pointed coagulating electrode is inserted per urethra alongside the ureteral catheter to describe and detach circumferentially an adequate bladder cuff around the ureteral orifice in a full thickness manner using glycine irrigation. The anterior traction afforded by the suprapubic grasper is a critical adjunct in facilitating this circumferential detachment of the bladder cuff from the adjacent bladder, as well as delivering the freed intact extravesical ureter into the bladder. Extravesical fibrofatty attachments of the juxtavesical ureter are released with the coagulating electrode, thereby circumferentially mobilizing the most distal 3–4 cm of en bloc ureter (Fig. 10.1c). The intramural ureter is circumferentially occluded by cinching down the already placed endoloop tie, thus precluding local urine spillage [16].

Nephroureterectomy

Three techniques for performing the nephrectomy have evolved over the past decade.

Transperitoneal Nephroureterectomy

Peritoneal access can be obtained by either the Veress needle (closed) technique or the Hasson cannula (open) technique, with the patient routinely in the lateral position. Typically, a four- to five-port approach is employed. For the laparoscope, a 12-mm primary trocar is inserted at the umbilicus or at the lateral border of the

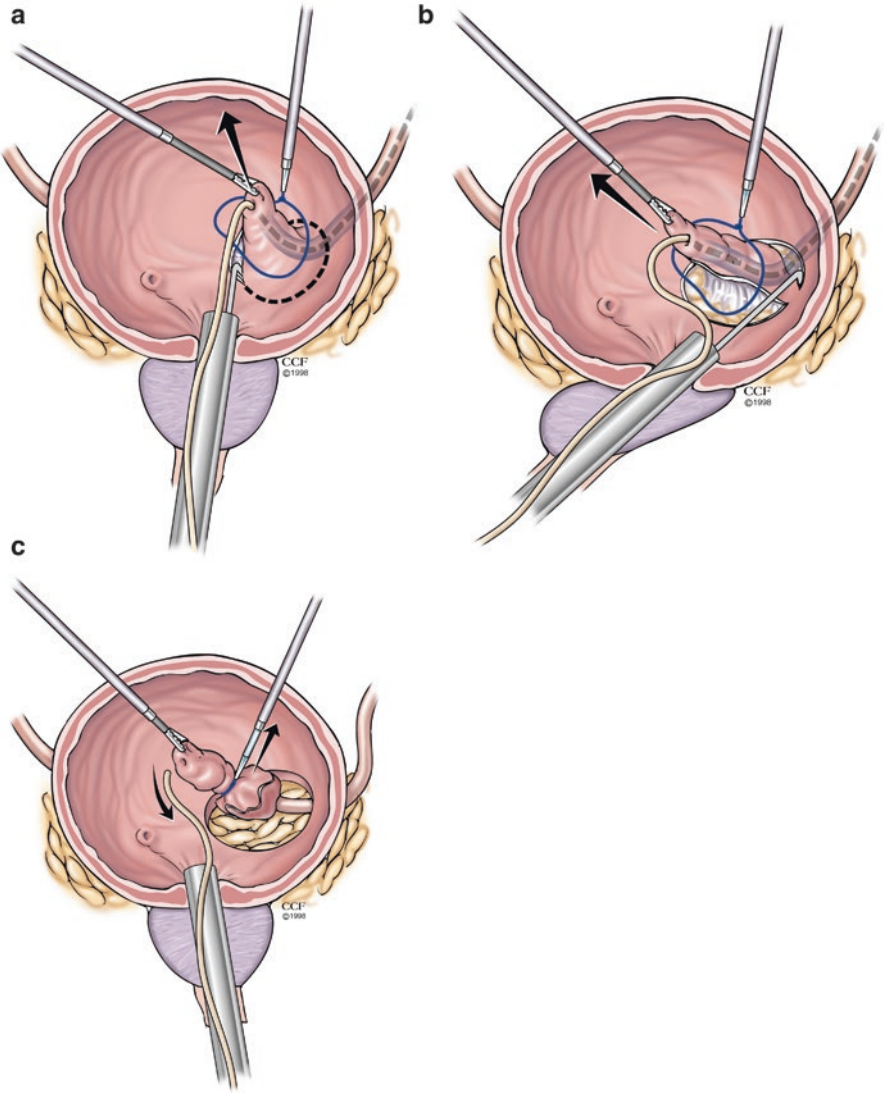

Fig. 10.1 (**a**) Figure illustrating the placement of two trocars (2 mm) in the bladder with ureteric catheter in the distal ureter and a loop encircling the orifice and Colin knife resectoscope, which creates the bladder cuff around the ureteric orifice. (**b**) Circumferential incision of the bladder mucosa and deep incision of the distal ureteric tissue are done with mobilization of the tissues further up to free the distal ureter. (**c**) Complete mobilization of the distal ureter with bladder cuff, followed by removal of the ureteric catheter and ligation of the distal ureter to avoid tumor spillage (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 1998–2010. All Rights Reserved)

rectus muscle one to two fingerbreadths cephalad to the umbilicus (10 mm, 30°). Three secondary trocars are placed—a 5-mm port at the lateral border of the rectus near the costal margin, a 12-mm port at the lateral border of the rectus one to two

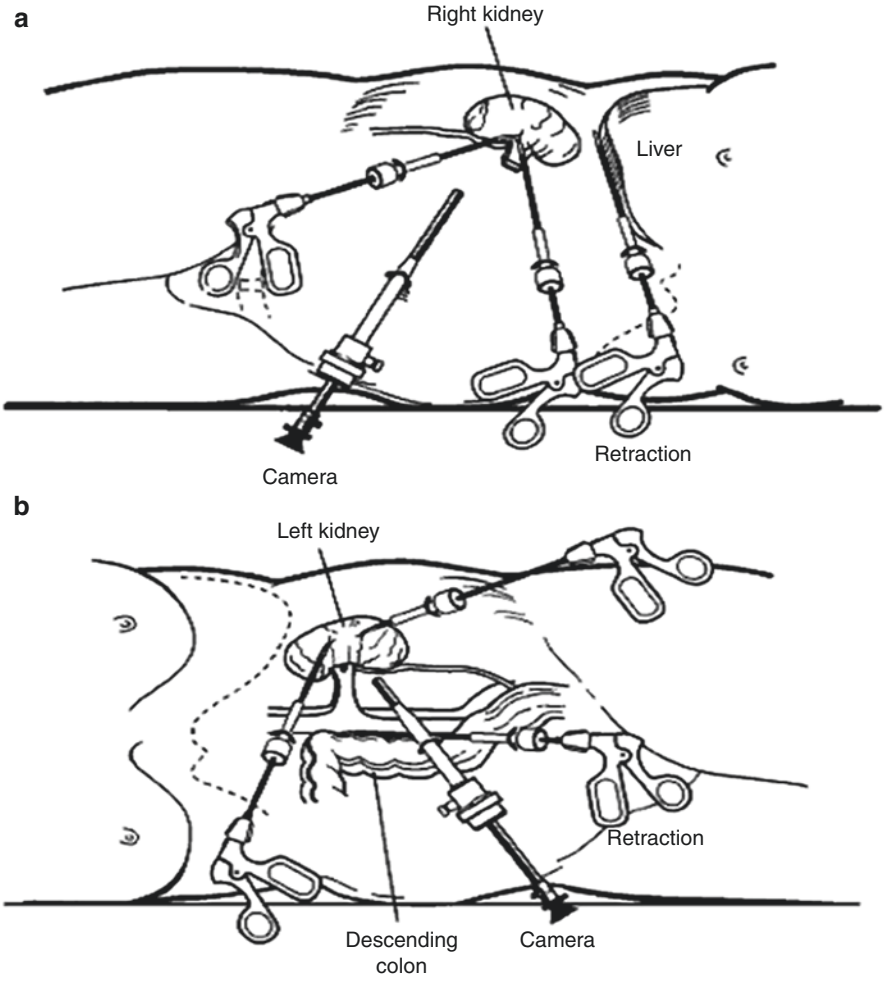

Fig. 10.2 A small accessory trocar can be placed for right- (**a**) and left- (**b**) sided procedures to aid with retraction of the liver, spleen, or bowel (This article was published in *Atlas of Laparoscopic Retroperitoneal Surgery*, Jarrett TW, Laparoscopic nephroureterectomy, pp. 105–120, Copyright Elsevier)

fingerbreadths below the level of the umbilicus, and a 5-mm port for lateral retraction of the kidney inserted at the anterior axillary line near the costal margin (Fig. 10.2). For a right-sided nephrectomy, an additional 5-mm port is necessary at the costal margin for cephalad retraction of the liver [30].

Using electrosurgical scissors and grasping forceps, the line of Toldt is incised from the hepatic or splenic flexure down into the pelvis across the iliac vessels. The incision is extended medial to the medial umbilical ligament. Dissection allows for complete mobilization of the bowel medially to expose the retroperitoneum. The dissection is then performed over the area of the iliac vessels to identify the ureter as it courses this region. Having secured the ureter in an umbilical tape for

retraction, it is dissected down into the pelvis. The superior vesical artery is dissected as it crosses the ureter, secured and transected. The medial umbilical ligament is also transected to complete the caudal dissection of the ureter down to the detrusor muscle. The ureter is completely freed until the detrusor muscle fibers at the ureterovesical junction are identified. At this point, by placing a grasping forceps through the lower anterior axillary line port, the ureter can be retracted superiorly and laterally, thereby tenting up the wall of the bladder to expose the ureterovesical junction. The open jaws of the endo-GIA stapler are placed across the cuff of bladder, then closed and fired to incise the tissue between staple rows.

Dissection cephalad along the ureter is then extended up to the renal hilar region. The renal artery and renal vein are circumferentially dissected and exposed. Vascular clips are used to secure the renal artery and a vascular endo-GIA stapler is used to secure the renal vein before transection. Dissection is performed outside of Gerota's fascia, freeing the kidney along the inferior, lateral, and posterior aspects. At the upper pole, dissection is completed through Gerota's fascia onto the upper pole of the kidney. In this manner the adrenal gland is left untouched and in situ [31].

Sealed Laparoscopic Nephroureterectomy [17]

A new technique performed to avoid the disadvantages of transurethral bladder cuff excision and open/laparoscopic distal ureterectomy using the endo-GIA. First, a standard laparoscopic transperitoneal nephrectomy in a full flank position is performed. Three ports are used: one 10-mm trocar is placed by the Hasson technique supraumbilically, one 5-mm port is placed in the midclavicular line in the ipsilateral upper quadrant, and one 12-mm trocar is placed above the first one in the midline between the xyphoid and the first port. An optional fourth 5-mm trocar may be inserted above the former trocar on the right side and in the anterior axillary line on the left side. After mobilization of the colon, the ureter is identified and clipped without transsection to prevent inadvertent urine spillage. The renal artery and vein are dissected and divided, and the kidney is circumferentially mobilized, sparing the adrenal. The ureter is then dissected caudally into the pelvis. An additional two (5- and 10-mm) trocars are placed in the lower abdomen (Fig. 10.3a). After transection of the lateral umbilical ligament, dissection is continued caudally until the detrusor muscle fibers at the ureterovesical junction are identified. The ureter is then retracted superior and laterally, tenting up the bladder wall at the ureterovesical junction. A 1-cm area of bladder adventitia around the ureterovesical junction is cleared, and a bladder cuff is incised with the use of a 10-mm LigaSure Atlas™ (Valleylab, Boulder, CO) (Fig. 10.3b). The bladder wall from one side and kidney together with the ureter and bladder cuff from the other side remain sealed after incision and detachment. Additional sutures on the bladder wall are not required [17].

Technical Caveats

Dissecting instruments and grasping forceps should be placed at an approximately 45-degree angle to the scope. If placed too low, instrument handling will be impaired by the iliac bone and if too high, the instrument tips will be too close to the kidney.

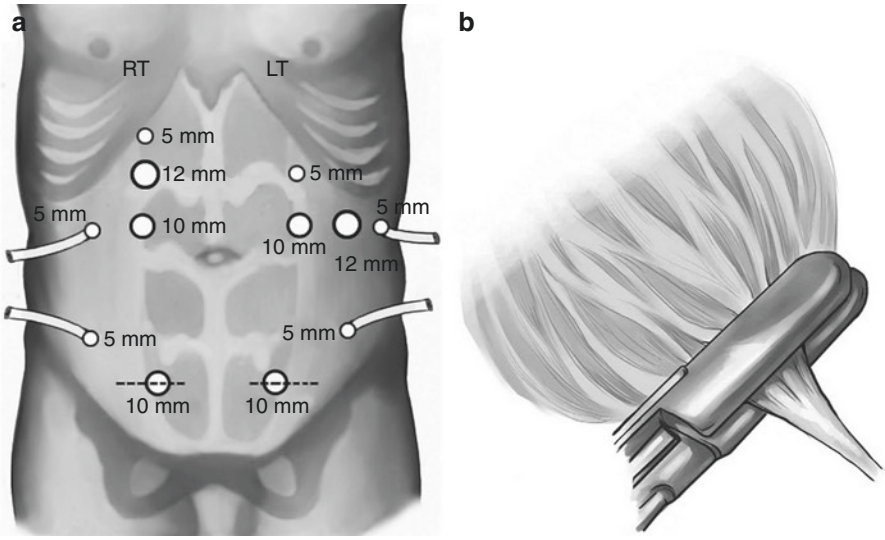

Fig. 10.3 (**a**) Schematics of trocar position. (**b**) The bladder cuff is incised by LigaSure Atlas™ (Valleylab, Boulder, CO). (Reprinted from Tsivian et al. [17], with permission from Elsevier)

Safe dissection of the renal hilum requires two conditions: (1) medial retraction of the colon and bowel by gravity or an additional retractor and (2) lateral retraction of the kidney by lifting it out of the renal fossa. Lateral retraction of the kidney with a grasper placed under the lower pole will place the vessels on tension. This is accomplished by gently placing the lateral grasper under the ureter and lower pole of the kidney until the grasper abuts against the abdominal sidewall. With the ureter and lower pole of the kidney elevated, layer-by-layer anterior dissection is performed with the irrigator aspirator until the renal vein is uncovered.

Transperitoneal: Hand-Assisted Nephroureterectomy

With hand-assisted NU, the kidney and proximal ureter are removed laparoscopically, and an incision is made for dissection of the distal ureter and bladder and intact specimen removal. This approach circumvents the difficulty in performing the most difficult portions of the procedure laparoscopically [23]. After pneumoperitoneum is achieved, the Pneumosleeve (Dexterity, Blue Bell, PA) device is assembled, which consists of a plastic wound protector that is inserted into the 7- to 8-cm incision and a clear plastic sleeve that is attached to the patient's skin by an adhesive ring similar to an ostomy disk. With this device, the surgeon's hand can be used for retraction and blunt dissection. This positioning works well for the right-handed surgeon working on a right kidney. For the right-handed surgeon working on a left kidney, however, a slightly higher periumbilical midline placement may be preferable. Relative to standard laparoscopic techniques, hand assistance seems to facilitate the operative speed and safety of laparoscopic nephrectomy (LN4) without significantly sacrificing the benefits of minimally invasive surgery [32, 33]. It also makes intact removal of the specimen easy.

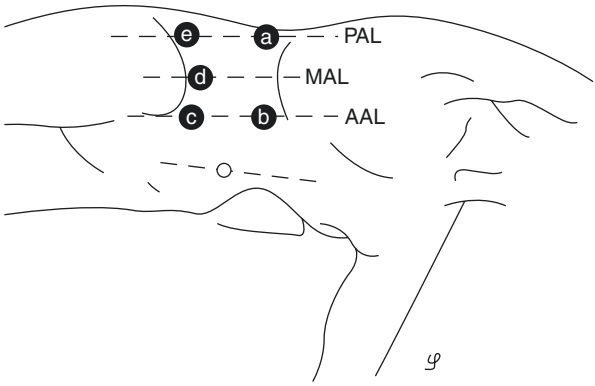

Fig. 10.4 Site of trocars. *a*, 12-mm trocar (suction-irrigation); *b*, 10-mm trocar (forceps); *c*, 5-mm trocar (forceps); *d,* 10-mm trocar (camera); *e*, 5-mm trocar (scissors). *PAL* posterior axillary line, *MAL* median axillary line, *AAL* anterior axillary line (Reprinted from Salomon et al. [35] With permission from Elsevier)

Retroperitoneal Nephroureterectomy

The retroperitoneal approach for nephroureterectomy for upper tract TCC recently was described by Gill and Salomon et al. Salomon et al. develops the retroperitoneal space with digital dissection, whereas Gill uses the trocar-mounted Origin balloon distension system (Origin Medsystems, Menlo Park, CA) [34, 35]. Patients were placed in the lateral decubitus position. 5 mm trocars (total 5 trocars) were used, including one 12 mm, two 10 mm, and three 5 mm. A 15-mm incision was made under the 12th rib on the posterior axillary line in front of the sacroiliac muscles. The retroperitoneum was entered by blunt dissection. The index finger was first used to push the peritoneum forward and then the index finger, protected by a latex finger cover, was placed in the retroperitoneum to guide the positioning of the other ports. A 10-mm trocar was placed at the apex of the 12th rib at the level of the anterior axillary line, a 5-mm trocar above the iliac crest at the level of the anterior axillary line, a 10-mm trocar above the iliac crest at the level of the median axillary line, and a 5-mm trocar above the iliac crest at the level of the posterior axillary line. The single 12-mm trocar was placed in the first incision made under the 12th rib on the posterior axillary line (Fig. 10.4). A pneumoretroperitoneum is created by applying 10–15 mmHg of CO_2 pressure. The initial maneuver is to clip ligate the upper ureter in continuity as a precaution to prevent urinary distention of the distal ureter. The renal artery and vein are individually controlled, and the renal specimen is circumferentially mobilized retroperitoneoscopically external to Gerota's fascia. If necessary, the adrenal gland is excised en bloc with the specimen. The ureter, along with en bloc gonadal vein and periureteral adipose tissue, are mobilized distally beyond the common iliac vessels. Gentle cephalad traction on the ureter with a laparoscopic 5-mm atraumatic small bowel clamp, combined with precise dissection with J-hook electrocautery, delivers the entire cystoscopically mobilized, intact distal ureter and bladder cuff into the upper retroperitoneum. Laparoscopic visualization of the prior intravesically placed endoloop tie around the intramural ureter provides assurance that the entire ureter has been retrieved without leaving any fragment of urothelium behind. The retroperitoneum

is inspected for bleeding, a suction drain is inserted, and the pneumoretroperitoneum is exsufflated. The laparoscopic ports are removed and the puncture site is closed using 2-zero polyglycolic acid sutures.

Specimen Entrapment and Delivery

The en bloc specimen is entrapped in an Endo Catch™ bag (Covidien, Dublin, Ireland) and extracted intact through an appropriate muscle splitting extension of the primary port site incision. The Endo Catch™ is a transparent sack that comes with a metal ring that readily opens the mouth of the sack when it is deployed (similar to a butterfly capture net), resulting in easy manipulation of the specimen into the sack. However, if a laparoscopic-assisted or open approach to the distal ureter has been used, then entrapment is not a necessary step because the specimen can be removed directly by the surgeon's hand.

Technical Caveats

During port placement, every effort should be made to separate out the ports as much as possible. Frustrating "clashing of swords" occurs if the trocars, and therefore the laparoscopic instruments, are located in close proximity. Thus, the anterior axillary line (AAL) port can be positioned even more anterior to the axillary line; however, the lateral peritoneal reflection must be clearly visualized laparoscopically and avoided before the AAL port is inserted. Similarly, care must be taken to avoid pleural injury during placement of the upper midaxillary line (UMAL) port. The 12-mm lower midaxillary line (LMAL) port must be located at a considerable distance (≥3 cm) cephalad to the iliac bone. The unyielding bone significantly compromises the torque capability of a trocar placed adjacent to it.

Detachment of the upper renal pole from the undersurface of the adrenal gland must be performed meticulously using a fore-oblique (30-degree) laparoscope and electrocautery for hemostasis. Persistent venous oozing from the adrenal bed can result in significant bleeding postoperatively.

Intraoperative Difficulties

Peritoneal Rent

A peritoneal rent may occur either initially during balloon inflation or subsequently during laparoscopic dissection. Usually a peritoneal rent does not cause significant problems, and the procedure can be completed retroperitoneoscopically. However, adequate medial retraction of the kidney by a fan retractor inserted through the UMAL port may be necessary to maintain operative exposure in the retroperitoneal space. Two points must be kept in mind: (1) intra-abdominal viscerae must be thoroughly inspected by inserting the laparoscope through the peritoneal rent to rule out iatrogenic injury, and (2) the peritoneal cavity must be drained of CO_2 prior to terminating the procedure.

Identification of the Renal Hilum

If the renal hilum cannot be located, the surgeon should reinsert the laparoscope slowly and identify the psoas muscle. The psoas muscle should then be crossed from lateral-to-medial in a cephalad direction and a search conducted for arterial pulsations near its medial border. Pulsations of the fat-covered renal artery or aorta are usually identifiable. Gentle dissection with the tip of the suction device and electrosurgical scissors or hook is performed directly toward the pulsations. The aorta or renal artery are identified and traced to the renal hilum. Alternatively, the ureter can be identified and followed cephalad to the hilum. Dissection through the perirenal fat may identify the surface of the kidney, which can then be dissected toward its hilum.

Persistent Hilar Bleeding After Ligation of the Renal Pedicle

Persistent renal hilar bleeding generally indicates the presence of an overlooked, patent accessory renal artery. After flow is controlled from the main renal artery, the renal vein should appear flat and devoid of blood. A normally distended renal vein at this juncture indicates continued arterial inflow through an accessory renal artery. In this circumstance, division of the distended renal vein with an endo-GIA stapler interrupts venous outflow with a resultant increase in intrarenal venous back pressure. This causes persistent oozing during the remainder of the dissection. One should search for an accessory renal artery in this situation.

Prolongation of Pneumoperitoneum and Intravesical Tumor Recurrence (IVR)

In a recent clinical trial it was found that prolonged peumoperitoneum over 150 minutes and presence of lymphovascular invasion were associated with an increased risk of intravesical tumor recurrence after laparoscopic robotic nephrourterectomy for upper tract urothelial carcinoma.

Port Site Recurrence

Port Site Recurrence (PSR) following laparoscopic tumor resections has been reported for a variety of tumors. Though PSR is a rare phenomenon, they most commonly occur following nephroureterectomies for upper tract urothelial carcinoma. Previous cases of upper tract urothelial carcinoma were reported. In a recent case report of a PSR following a robotic assisted nephroureterectomy for the sarcomatoid variant of urothelial carcinoma of the upper urinary tract was described [36]. Prolonged peuomoperitoneum can casue port site seeding during laparoscopic surgery for upper tract urothelial tumors [37].

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