Retroperitoneal Laparoscopic Radical Nephrectomy

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1 Introduction

Laparoscopic renal surgery has emerged as an equally efficacious with minimally morbidity alternative to open radical nephrectomy for selected kidney tumors [1, 2]. Classical radical nephrectomy as described by Robson [3] consists of several principles; the most fundamental principle is en-bloc dissection of the tumorous kidney outside the renal fascia. Laparoscopic radical nephrectomy (LRN) aims to replicate established open surgical procedures using the transperitoneal or retroperitoneal approach. In comparison to the transperitoneal approach, the retroperitoneal approach allows the surgeon to achieve rapid and straightforward access to the renal hilum.

Approach for retroperitoneal laparoscopic radical nephrectomy (RRN) is not standardized; it is performed according to center and surgeon preference. Intimate knowledge of the renal anatomy as well as the surrounding retroperitoneal structures is required in order to safely and effectively dissects along the proper surgical planes. The retroperitoneum lies between the posterior parietal peritoneum anteriorly and the transversalis fascia posteriorly. Since Gerota described the fascia layer around the kidney in 1895, anatomists and radiologists had studied this fascia for many years. Currently, Meyers and other authors in a series of articles [4–7] proposed the generally accepted viewpoints. There are at least three fasciae structures presented around the kidney: the anterior renal fascia (Gerotas fascia), the posterior renal fascia (Zuckerkandl fascia), and the lateroconal fascia. The retroperitoneum is divided into three distinct compartments by perirenal fascia (Fig. 5.1). The anterior pararenal space is located between the parietal peritoneum and the

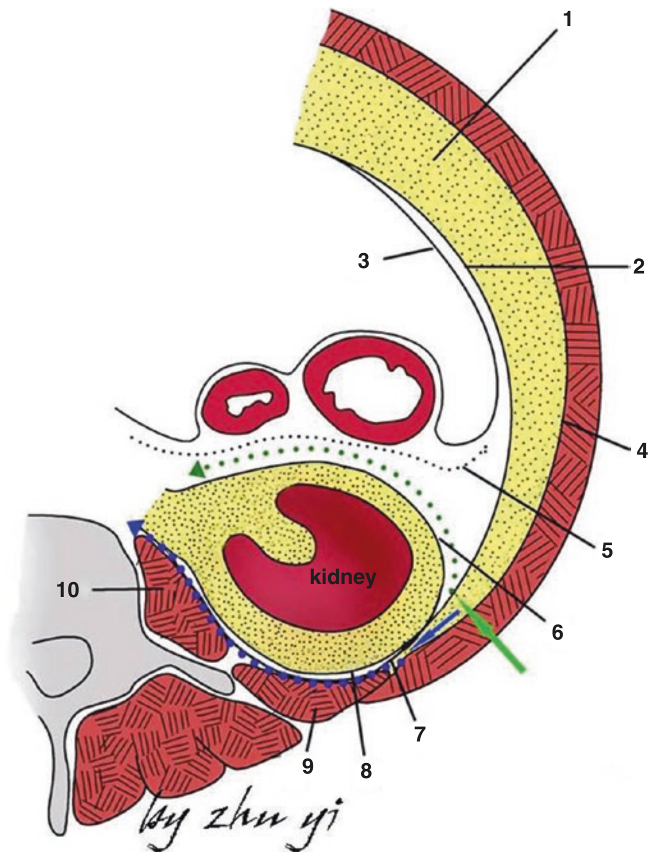

Fig. 5.1 Cross-section of kidney and perirenal fascial structures at the level of the renal pedicle (schematic diagram). The green arrow and dotted lines demonstrated the area of incision for the lateroconal fascia, and the anterior dissection in the anterior perirenal space. The blue arrow and dotted lines indicated the posterior plane of dissection in the anterior psoas space. (*1*) Pararenal fat. (*2*) Lateroconal fascia. (*3*) Parietal peritoneum. (*4*) Transversalis fascia. (*5*) Fusion fascia. (*6*) Anterior renal fascia. (*7*) Outer layer of the posterior renal fascia. (*8*) Inner layer of the posterior renal fascia. (*9*) Quadratus lumborum muscle. (*10*) Psoas major muscle. The outer layer of the posterior renal fascia was fused with the fasciae of the quadratus lumboru muscle and psoas muscles

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anterior renal fascia. Superiorly it extends to the dome of the diaphragm, inferiorly it communicates with the pelvis. The perirenal space is located between the anterior and posterior renal fasciae. The posterior pararenal space is located between the posterior renal fascia and the transversalis fascia containing only fat. It extends toward the pelvic cavity inferiorly but is limited medially by fusion of the posterior renal fascia with the fascia of the quadratus lumborum and psoas muscles. Accurate anatomical recognition of the perirenal space and the fascia enveloping the kidney are the keys to perform radical nephrectomy.

2 Indications and Contraindications

The indications for retroperitoneal laparoscopic radical nephrectomy are similar to the indications for open radical nephrectomy. RRN can be expended to more challenging cases after gaining more experience. Indications for RRN are as below:

1. Organ-confined T1-T2 malignant renal tumors, not amenable to a partial nephrectomy
2. T3a and even T3b renal tumors, depending on the surgeon's expertise
3. Upper tract urothelial carcinoma, requiring removal of the ipilateral ureter and ureteral orifice

The usual contraindications for RRN:

1. Patient with uncorrected coagulopathy
2. Patient who are medically unfit for general anesthesia.
3. Patient with past history of retroperitoneal lumbar surgery

Excessively large tumor size, and locally advanced renal cell carcinomas that has invaded adjacent structures or to the inferior vena cava thrombus are relative contraindications, depending on the surgeon's experience and the characteristics of the individual tumor.

3 Preoperative Evaluation and Patient Preparation

3.1 Preoperative Evaluation

The preoperative evaluations for retroperitoneal laparoscopic radical nephrectomy are same as an open procedure:

1. History taking and physical examination
2. Basic laboratory studies: full blood count, coagulation profile, liver function test, renal profile, fasting blood glucose, urine FEME, blood cross-matched electrocardiogram, chest radiograph
3. Special imaging examination: 4 phase contrasted computed tomography (CT) urogram (assessing the tumor size and location, local and regional extension), CT angiography or MRA(defining and quantifying the possible vascular invasion and aberrant vessels), nuclear medicine renal scan or bone scan (if indicated), 3D computed tomography reconstruction imaging

3.2 Patient Preparation

Informed consent should be obtained together with a discussion of possible complications. Patients must be consented for conversion to open surgery. Anticoagulant medications must be discontinued before surgery. The patient must fast starting at midnight on the night before surgery. Bowel preparation is optional. Prophylactic antibiotics are administered during induction of general aneasthesia. IV Cefazolin 1 g usually provides adequate coverage in non-allergic patient. Pneumatic compression stockings are applied preoperatively for deep vein thrombosis prevention. Foley catheter is routinely used while nasogastric tube is optional.

4 Step-by-Step Operative Technique

Based on anatomical features of the renal area, we summarized the entire surgical procedure to be carried out along "two spaces" and "two poles". Anterior dissection of the kidney is performed within the anterior pararenal space involving mobilization of anterior renal fascia from fusion fascia. Posterior dissection is performed within the anterior psoas space (part of the posterior pararenal space; Fig. 5.1). The superior dissection is performed up to the subdiaphragmatic level and the distal dissection is performed until the iliac fossa. Tissue dissection and hemostasis from small vessels were achieved using a harmonic scalpel (Ethicon Endo-Surgery, Johnson and Johnson, Cincinnati, OH, USA).

Patient positioning and trocar placement are described Chap. 1: Establishment of retroperitoneal approach for laparoscopic adrenal gland and upper urinary tract surgery.

We prefer the retroperitoneal approach with the three-port technique as previously described (see Sect. 1: Chap. 1) (Fig. 5.2). A 2-cm skin incision is made under the 12th rib on the posterior axillary line anterior to the sacrospinal muscle. The muscular layer and lumbodorsal fascia were bluntly divided with a long hemostatic forcep. Index finger is inserted into the retroperitoneal space (posterior pararenal space), and bluntly dissects the adipose tissue from superior to inferior and from posterior to anterior, at same time pushes the peritoneum anteriorly. The space is subsequently expanded with a balloon expander (Fig. 5.3). Six hundered to eight hundred milliliters of air is insufflated into the balloon for an average-sized adult. Subsequent insertion of trocars will be guided by index finger from the retroperitoneal space. A 10 mm camera trocar (Trocar B) is inserted two fingers breadths above the iliac crest on midaxillary line; trocar C is inserted at the subcostal margin on anterior axillary line; trocar A is inserted via the initial skin incision and the skin incision is sutured to fix the trocar. Twelve millimeters trocar will be inserted on the side of dominant hand. Pneumoretroperitoneum is created by CO_2 insufflation via camera trocar (pressure range, 10–12 mmHg). Surgeon operates at the backside of the patient (using Trocar A and C). The assistant (camera operator) works at the abdominal side (using Trocar B).

4.1 Mobilization of Retroperitoneal Adipose Tissue and Exposure of the Deeper Fascial Structures

Retroperitoneal adispose tissue is mobilized from the infraphrenic fossa superiorly to iliac fossa inferiorly, from peritoneal reflection anteriorly to psoas major posteriorly. The lateral conical fascia is exposed (Fig. 5.4) and is subsequently longitudinally incised posterior to the retroperitoneal fold (Fig. 5.5).

Fig. 5.2 Trocars configuration for left retroperitoneal laparoscopic nephrectomy

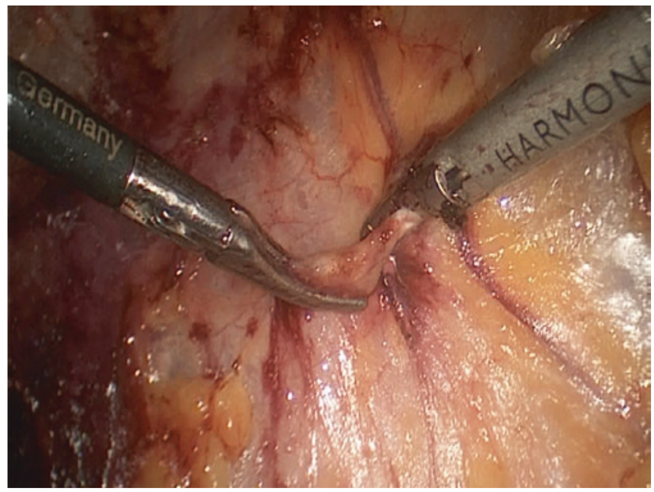

Fig. 5.4 The lateral conical fascia is exposed

Fig. 5.3 Home-made balloon expander

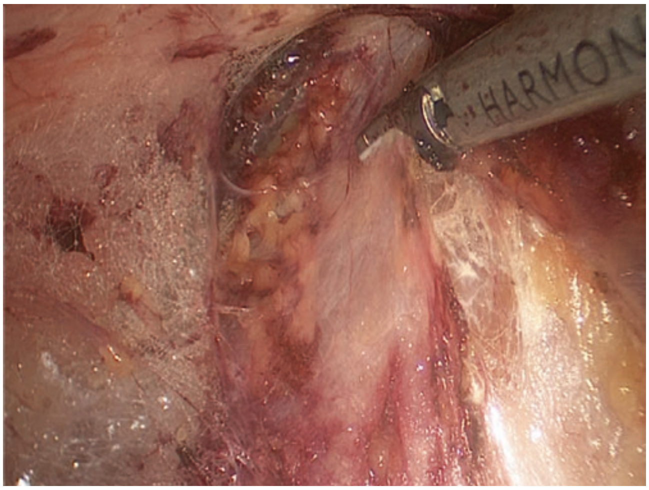

Fig. 5.5 The lateral conical fascia longitudinally incised posterior to the retroperitoneal fold

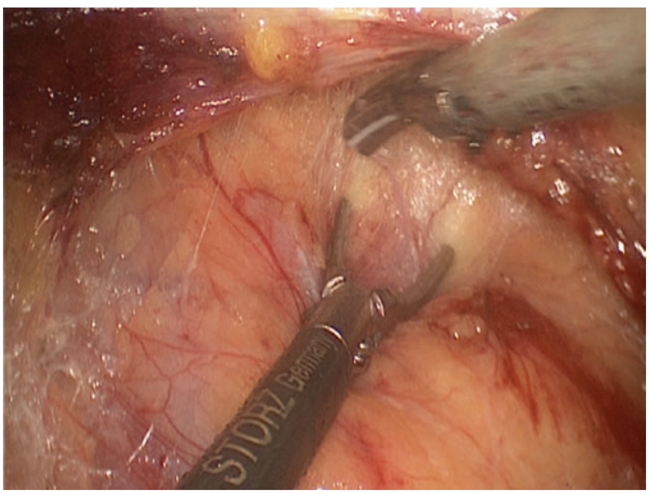

Fig. 5.6 Anterior pararenal space is exposed

4.2 Anterior Dissection of the Kidney and Entering the Anterior Pararenal Space

Different from the usual RRN procedure where posterior dissection is the first step in kidney mobilization [8, 9], we prefer to dissect anterior plane first. Dissection is progressed meticulously between the fusion fascia (the fascia posterior to mesocolon) and the anterior renal fascia on the inferomedial pole of the kidney, entering the first avascular plane (anterior pararenal space) (Fig. 5.6). The white loose areolar tissue is identified as the landmarks for the correct avascular plane [10]. This dissection is complete until a cave-like gap is created (we named this created space as "bird's nest"; Fig. 5.7).

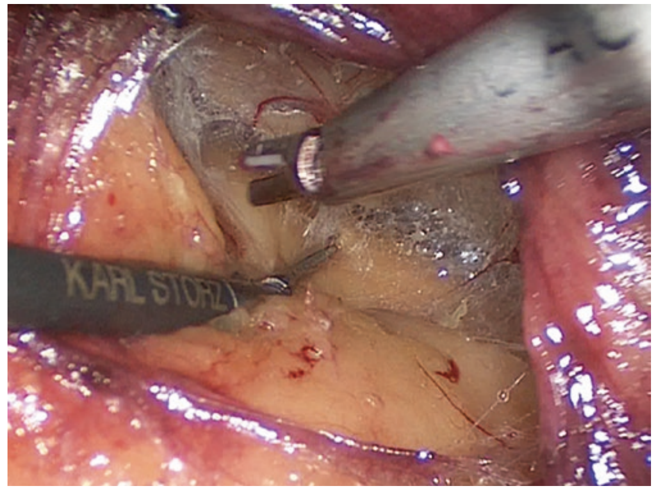

Fig.5.7 A cave-like gap is created in anterior pararenal space

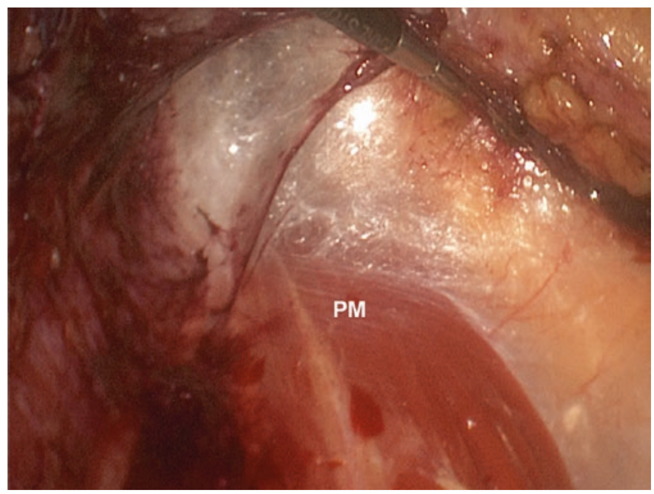

Fig. 5.8 Dissection is performed in the dorsal side of the posterior renal fascia and the psoas major is exposed (*PM* psoas major)

4.3 Posterior Dissection of the Kidney: Entering the Anterior Psoas Space (Part of the Posterior Pararenal Space)

Dissection is performed outside the fascia between the posterior renal fascia and the psoas major. As the renal fascia fused with the quadratus lumborum fascia, these two fascias are always dissected together to expose the muscle fibers of deeper psoas (Fig. 5.8). This plane is extended superiorly to the diaphragm and inferiorly to the iliac fossa. The inferior vena cava will be interior to the psoas major (Fig. 5.9).

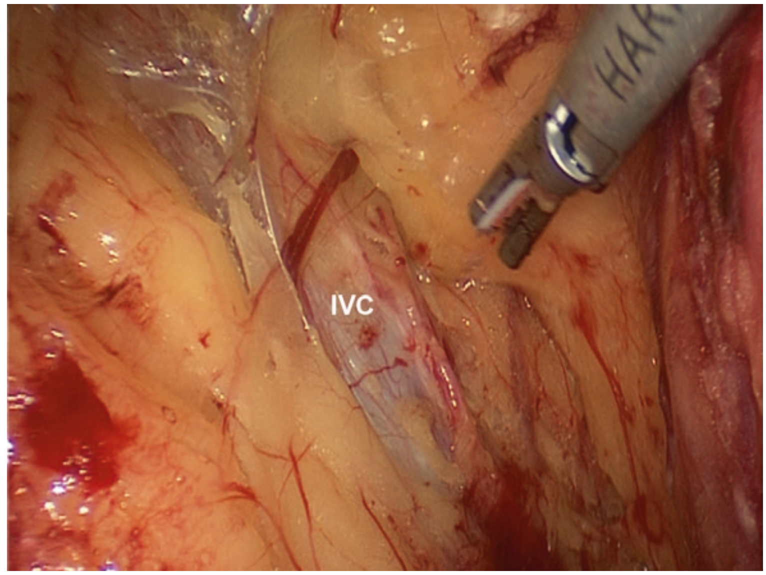

Fig. 5.9 The inferior vena cava will be interior to the psoas major (*IVC* Inferior vena cava)

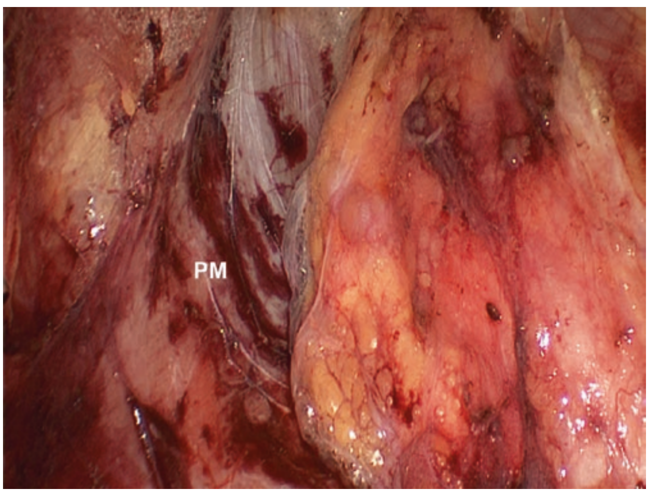

Fig. 5.10 Dissection is performed on the dorsal kidney along the psoas major extended up to infraphrenic space (*PM* psoas major)

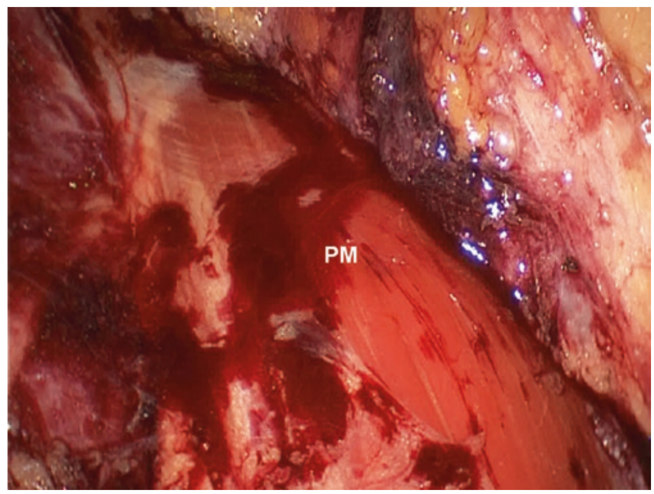

Fig. 5.11 Dissection is performed on the dorsal kidney along the psoas major extended down to iliac fossa (*PM* Psoas major)

4.4 Exposure of the Renal Hilum

Dissection is performed on the dorsal kidney along the psoas major with the extend from the infraphrenic space to the iliac fossa (Figs. 5.10 and 5.11). The kidney is retracted ventrally, renal vessels can be identified based on the characteristic of the pulsations. Sharp, well-defined pulsations reveal the location of fat-covered arteries (Fig. 5.12). Right angle forceps is applied to expose the renal hilum (Fig. 5.13). Hem-o-Lok is used in clipping the renal artery (Fig. 5.14). The inferior vena cava and renal vein can be observed after ligating renal artery (Fig. 5.15). The renal vein is subsequently clipped and transected with two Hem-o-lok clips at the vascular stump and one at the renal side (Fig. 5.16). An engorged renal vein after ligation of artery indicates that there is still artery supplying the kidney. The ligated renal artery may be just a branch or there is presence of aberrant artery that

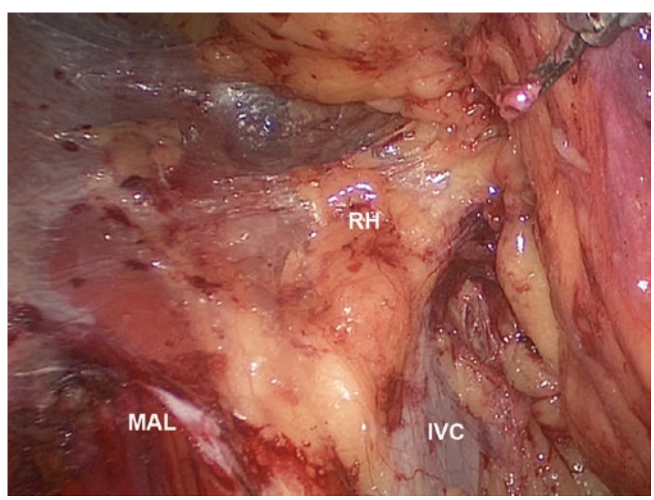

Fig. 5.12 Anatomy recognition in renal hilum (*RH* renal hilum, *MAL* medial arcuate ligament, *IVC* inferior vena cava)

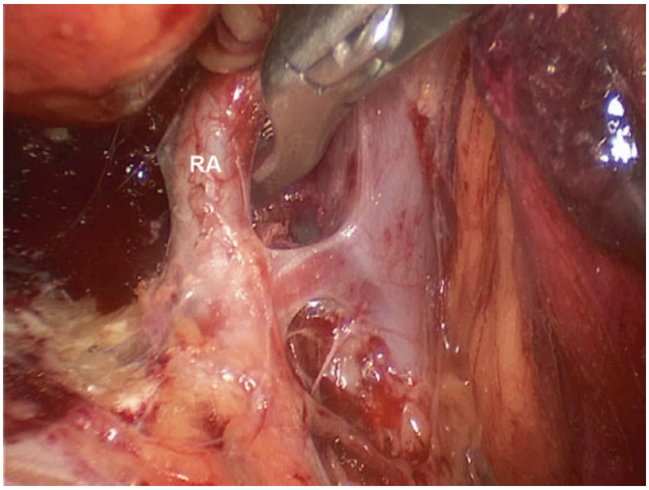

Fig. 5.13 Right angle forceps is applied to expose the renal hilum (*RA* renal artery)

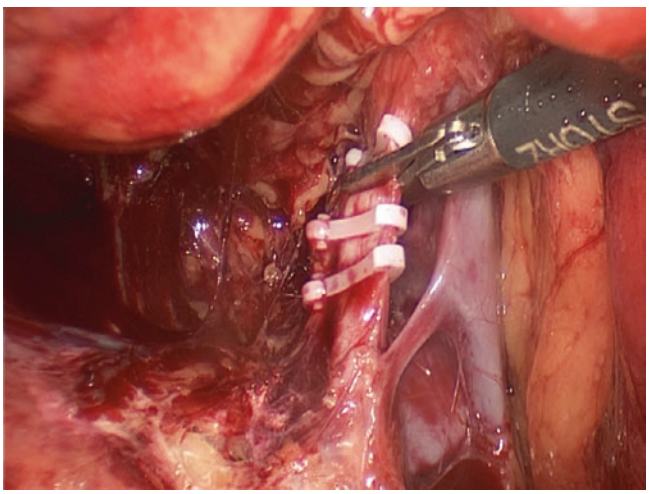

Fig. 5.14 Right renal artery is clipped

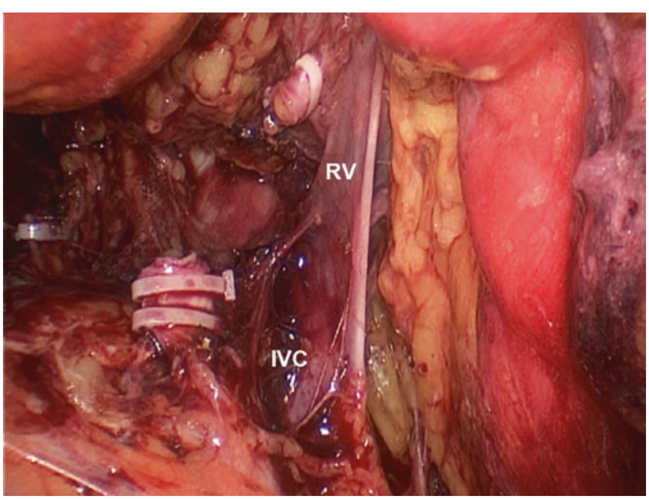

Fig. 5.15 The inferior vena cava and renal vein can be observed after ligating renal artery (*RV* renal vein, *IVC* inferior vena cava)

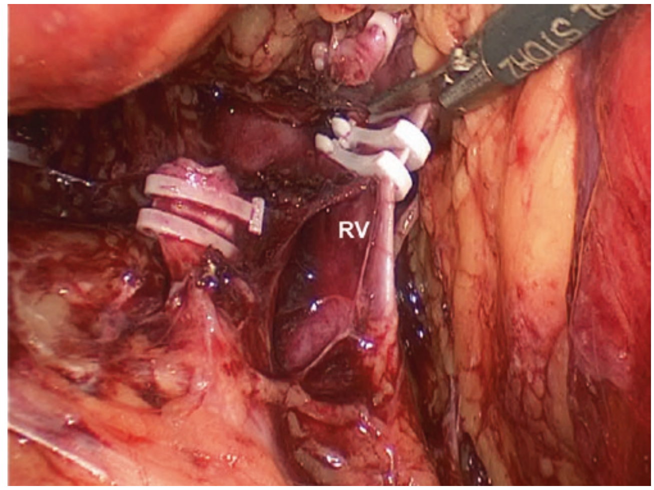

Fig. 5.16 The renal vein is subsequently clipped and transected with two Hem-o-lok clips at the vascular stump and one at the renal side (*RV* renal vein)

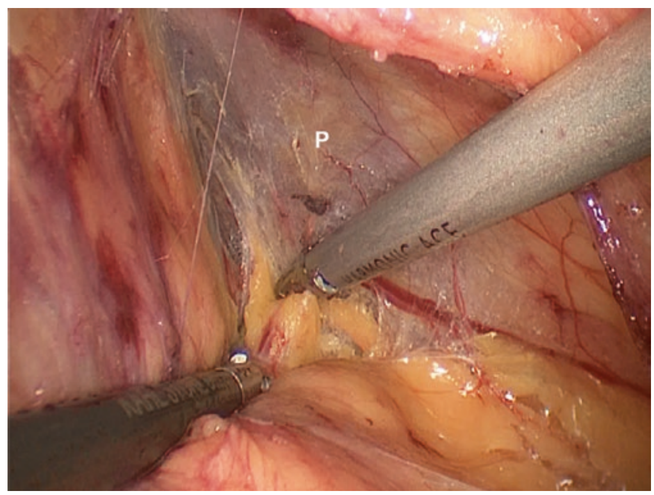

Fig. 5.17 The anterior pararenal space is continuously extended (*P* peritoneum)

which needs to be identified. The gonadal, lumbar, adrenal veins can be mobilized and secured with clips separately, especially for left-sided nephrectomy.

4.5 Redirection Towards the Previous Dissected Anterior Space

Continuous expand the space of the previously dissected cave-like gap (bird nest) (Fig. 5.17). Ultimately, the anterior space and the posterior space are extended until they join together superiorly just below the diaphragm, and inferiorly at the iliac fossa.

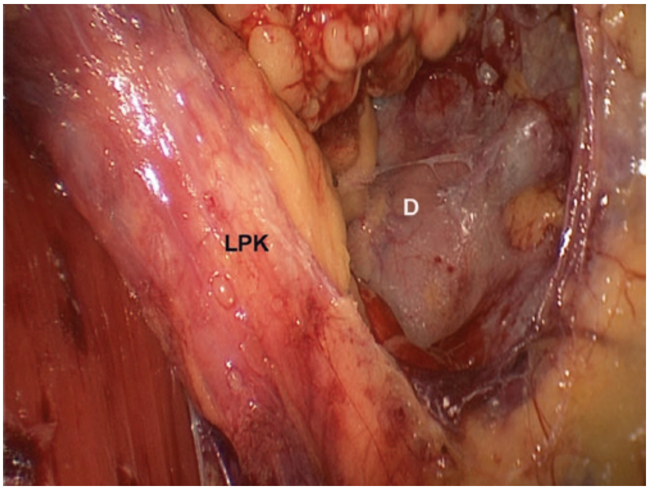

Fig. 5.18 Expand the space of the lower pole of ventral side of kidney (*LPK* lower pole of kidney, *D* duodenum)

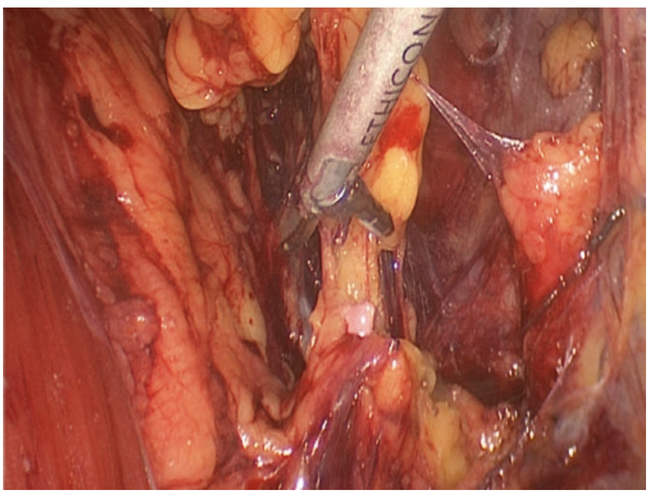

Fig. 5.19 The ureter and gonadal vein are covered by renal fascia and the remnant of the lower poles

4.6 Mobilization of the Upper and Lower Poles of the Kidney

Expand the space of the lower pole of ventral side of kidney (Fig. 5.18). The ureter and gonadal vein are covered by renal fascia and the remnant of the lower poles (Fig. 5.19). They are mobilized, clipped and divided (Fig. 5.20). If adrenal gland is to be preserved, the plane of dissection is between the upper pole of kidney and the adrenal gland (Figs. 5.21 and 5.22).

4.7 Specimen Entrapment and Extraction

The specimen is excised en bloc covered by renal fascia (Fig. 5.23) and manually extracted intact in an EndoCatch

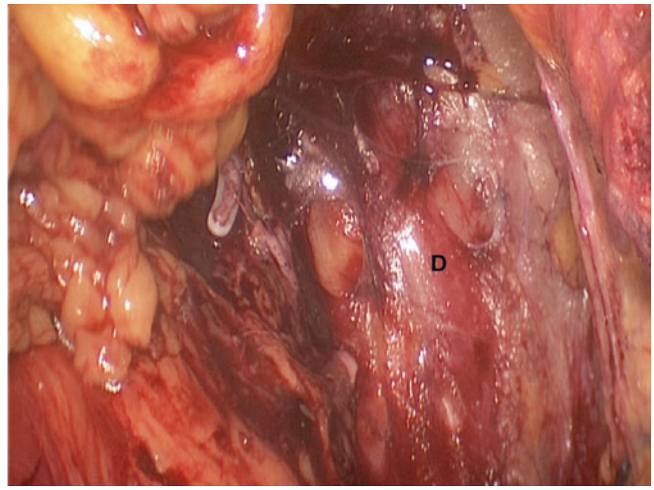

Fig. 5.20 The ureter and gonadal vein are mobilized and clipped (*D* duodenum)

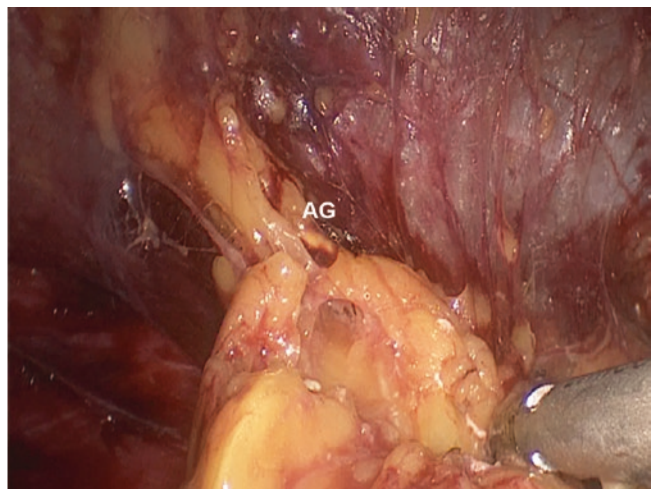

Fig. 5.21 The plane of dissection is between the upper pole of kidney and the adrenal gland (*AG* adrenal gland)

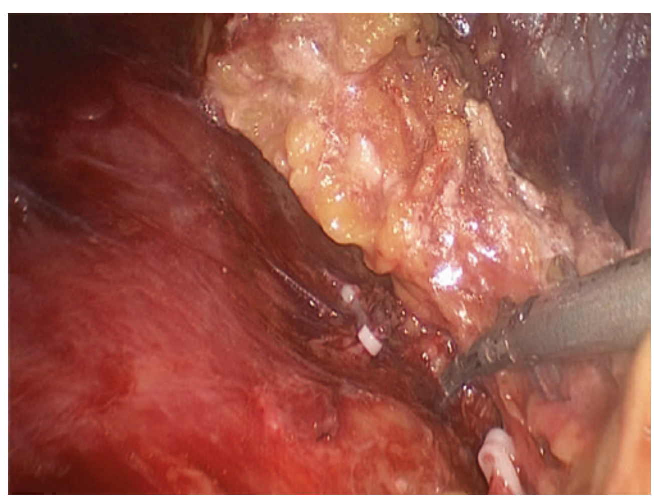

Fig. 5.22 The adrenal gland is preserved

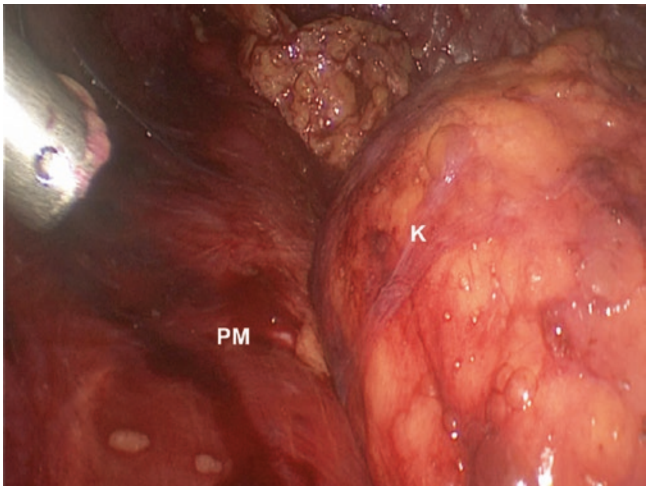

Fig. 5.23 The specimen is en bloc excised (*PM* psoas major, *K* kidney)

entrapment sac (US. Surgical, Norwalk, CT, USA). The specimen was extracted via extended skin incision between the second and the third trocar site to 5–7 cm (Trocar A and B, depending on the tumor size). After removal of the specimen, the pressure of the retroperitoneum is reduced to 5 mmHg to check for possible bleeding. Once hemostasis is secured, a drain tube is inserted via the second trocar (camera trocar), and the surgical incision is closed with 2/0 polyglycolic acid sutures.

5 Postoperative Management

Patient can be allowed for oral intake generally 1 day after surgery, started with clear fluids and stepped up as tolerated. Indeed, most patients do not have active bowel movement and flatus until postoperative day 2 or 3. Parenteral antibiotic is continued postoperatively. The Foley catheter is usually removed day after the surgery, and the drain is removed once the drainage is minimal. Patient is encouraged for mobilization day one post-operatively. Mean duration of hospital stay (including the day before the surgery and the day of the nephrectomy) is 5–7 days. Patients can gradually resume normal activities after hospital discharge, vigorous activities are limited for at least 1 month after surgery.

6 Complications and Management

Common complications of retroperitoneal laparoscopic radical nephrectomy are similar to those associated with open surgery, including injury to adjacent organs, bleeding, infection. In addition, laparoscopic nephrectomy is associated with insufflation-related complications including subcutaneous emphysema and gas embolism. Diaphragm injury is rare, surgeon need alert aware about it to avoid pneumothorax. Precise knowledge of the renal anatomy and surrounding retroperitoneal structures, meticulous dissection are important to prevent these complications.

6.1 Peritoneum Injury

The most common intraoperative minor complication is peritoneum injury. In our experiences, peritoneum injury will not cause significant problems, and the procedure can still be completed with retroperitoneum approach. If the peritoneal injury is small, pneumoperitonium pressure is decreased and injury is occluded with the Hem-o-lok. When operative exposure is compromised, especially in obese patients, an additional 5-mm trocar can be inserted into the abdominal cavity to drain the CO_2.

6.2 Bleeding

Bleeding may occur during the dissection of the renal hilum or renal mobilization. The vascular injuries are generally due to venous bleeding. These injuries may involve the main renal vein and its tributaries, (especially on the left side), the vena cava, inferior phrenic vessels, occasionally the aberrant vessels. Bleeding from the small vessels can usually be controlled it by bipolar coagulation. Otherwise, when the bleeding is troublesome, pneumoperitoneum pressure can be increased to 15–25 mmHg to provide tamponade effect. Subsequently, bleeders can be identified by using suction apparatus and guaze, and secured with clips or sutures. Bleeding from the renal hilum may need to controlled with stapler device. The surgeon should decide promptly for conversion to open procedure, once the bleeding is anticipated cannot be controlled.

6.3 Injuries of the Adjacent Organs

After ligation of renal pedicles, the kidney is sequentially mobilized using blunt and sharp dissection. We usually prefer to dissect the anterior aspect first. If dense adhesion or bleeding is encountered, dissection need to be performed in great care to avoid injury to the adjacent organs. On the right side, the duodenum, right colon and liver are the adjacent organ; whereas on the left side, the spleen, the left colon, and the tail of the pancreas are the adjacent organ. Electrocautery should not be used near to the peritoneum, to avoid potential thermal injury to intra-abdominal viscera.

7 Special Considerations

7.1 Kidney Mobilization

The general principle of surgical oncology is to excise the entire tumor with an adequate surgical margin. In radical nephrectomy, the basic surgical oncological principle is en-bloc resection of the diseased kidney at the renal fasciae, including perinephric fat and ipsilateral adrenal fat3 achieve a better oncological outcome.

In 1993, Gaur [11] reported the first retroperitoneal laparoscopic nephrectomy. Since then, several techniques for retroperitoneal laparoscopic radical nephrectomy had been described [12–15]. These techniques involved renal fascia incision at renal hilum near the parietal peritoneum reflexion, perirenal fat was exposed and part of the renal fascia was left over; which did not apply to the principle of radical nephrectomy. Based on laparoscopic anatomical studies, we observed two potential relatively bloodless planes external to the renal fascia; which were the plane between the fusion fascia and the anterior renal fascia at the anterior aspect and the plane between the posterior renal fascia and the lumbar muscles at the posterior aspect. Posterior renal fascia was fused with the fascia of the quadratus lumborum and psoas muscles and would be dissected together as one fascia.

Identification of the correct anterior and posterior anatomical planes at the renal fascia is the main factor for a good radical nephrectomy. Recognition of the lateroconal fascia and peritoneum reflexion is crucial for anterior dissection. We proposed incision of lateroconal fascia near the peritoneum reflexion and dissection between the fusion fascia and the anterior renal fascia until creation of a cave-like space. This technique complies to the oncological principle of minimum manipulation of a tumorous kidney. Subsequently, mobilization the dorsal side of the kidney and dissection the renal pedicle are performed. This technique offers a distinct advantage. If posterior aspect is dissected first, the entire kidney would be pressed and pushed anteriorly under air pressure, resulting tight adherence of the anterior renal fascia to the peritoneal and a higher risk of peritoneal injury. In our experience, this complication can occur even with an experience surgeon.

Some authors routinely incise the renal fascia near the psoas muscles during posterior dissection. We do not carry out this conventional practice as we mobilize the kidney at the posterior renal fascia. In view of the posterior renal fascia is fused together with the fasciae of the quadratus lumborum and psoas muscles, these fasciae ware always dissected together, without incising the renal fascia. There was no negative impact on the lumbar muscles from our experience.

7.2 Concomitant Adrenalectomy

Adrenalectomy as part of radical nephrectomy is one of the most controversial areas in urooncology. Up to today, there is no universal accepted recommendation. The decision to perform simultaneous adrenalectomy is individualized based on radiological and intraoperative findings [16]. In our practice, concomitant adrenalectomy is recommended if any abnormity of the adrenal gland has been found on preoperative CT scan. In additional, an upper pole or large tumor invading the adrenal gland mandates adrenalectomy.

7.3 Specimen Extraction: Intact or Morcellation

In earlier studies, most surgeons and medical institutions advocated morcellation of the specimen in a specimen “bag” to minimize the risk of tumor cell spillage and seeding. Recently the most author preferred intact specimen extraction as it allows precise pathologic staging [17–19].

7.4 Lumbar Tributaries of the Left Renal Vein (Fig. 5.24)

Injury to the posterior lumbar tributaries of the left renal vein may result in significant complications [20–22]. The lumbar tributaries of the left renal vein are variably sized, thin walled vessels that usually enter the left renal vein from a posterior location [23]. Lewis et al. [24] found that posterior lumbar tributaries have the most intra-individual variation, they stated that these vessels are “the most difficult to display and control at laparoscopic donor nephrectomy.” Thus understanding the detail anatomy of the posterior lumbar tributaries will help the surgeon (especially the novice) to avoid the potential risk of vascular injuries during renal surgery.

8 Future Perspectives

Since retroperitoneal laparoscopic radical nephrectomy was first introduced to the urological community in the early 1990s, this operation had constantly evolved. With the growing of surgeon expertise and emerging of new instrumentation, laparoscopic radical nephrectomy has expended to more challenging cases. Renal tumour with renal vein and subhepatic inferior vena caval tumor thrombus be managed laparoscopically [25–29]. The da Vinci Surgical System that is equipped with 3D vision and dexterous “EndoWrists”, enable nephrectomy for advance tumour with IVC tumor

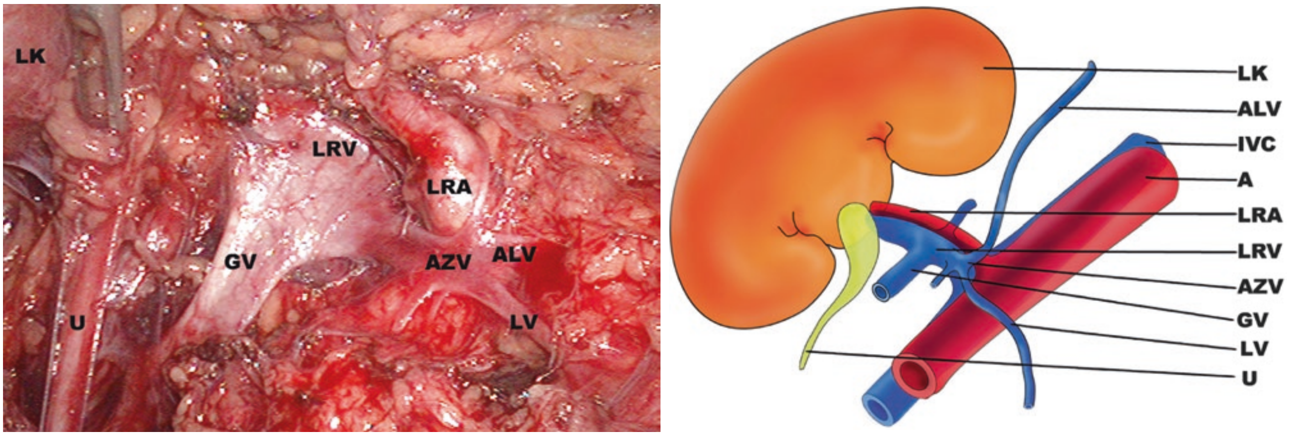

Fig. 5.24 Lumbar tributaries of the left renal vein (*LRA* left renal artery, *LRV* left renal vein, *AZV* reno-hemi-azygo-lumbar trunk, *ALV* left ascending lumbar vein, *GV* gonadal vein, *LV* lumbar vein, *IVC* inferior vena cava, *A* aorta, *LK* left kidney, *U* ureter)

thrombus can be performed this procedure can be performed easily and safely, especially for the patients with vena caval tumor thrombus [30–32]. We believe that Robotic-assisted approach will become the new standard treatment for challenging renal cell carcinoma in the future.

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