# 24 Laparoscopic Partial Nephrectomy

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## 24.1 Introduction

The widespread use of imaging techniques, such as computed tomography (CT) and ultrasound (US), has resulted in an increased detection of incidental renal lesions (Mevorach et al. 1992). The majority of these tumors are small and well localized. Radical nephrectomy is still considered the gold standard for localized renal cell carcinoma, yet nephron-sparing surgery (NSS) has gained more popularity over the past 10–15 years. Originally, NSS was reserved for patients with a solitary functioning kidney; now, it has become an option for selected patients with renal small tumors (<4 cm) and a normal contralateral kidney (Fergany et al. 2000).

Over the past few years laparoscopic surgery has become more popular than open surgery due to the advantages of small incisions, minimal postoperative pain, and early return to normal activities. Successful laparoscopic partial nephrectomy (LPN) on a porcine was first reported in 1993 (Shalhav et al. 1998). Later the same year, two groups reported successful clinical LPN in patients with benign disease (Winfield et al. 1995).

Unlike laparoscopic radical nephrectomy, the laparoscopic partial nephrectomy has proved to be a technically demanding procedure that requires an experienced laparoscopic urologist. Hemostasis during dissection of renal parenchyma presents a major challenge; however, experience with laparoscopic partial nephrectomy is growing and a number of centers have reported promising results (McDougall et al. 1998; Rassweiler et al. 2000; Simon et al. 2003). This chapter outlines the various LPN techniques and results with emphasis on the imaging evaluations that help to guide the surgeon for a successful outcome.

## 24.2 Indications and Contraindications

### 24.2.1 Indications

Laparoscopic partial nephrectomy has been successfully performed for benign and malignant conditions:

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1. Benign diseases treated with laparoscopic partial nephrectomy:
   a. Poorly functioning renal moieties associated with ureteral duplication or horse shoe kidney.
   b. Hydrocalix with urolithiasis.
   c. Recurrent renal infection.
   d. Equivocal renal cyst.
   e. Indeterminate solid renal mass.
2. Malignant diseases treated with laparoscopic partial nephrectomy; renal cell cancer (RCC), for example, which meets the following criteria:
   a. Tumor size <4 cm.
   b. Unilateral tumor.
   c. Absence of multifocality.
   d. Location of the tumor should not be too close to the renal hilum to allow partial nephrectomy without injury to the major vessels or the renal pelvis.

### 24.2.1 Contraindications to Partial Nephrectomy

Laparoscopic partial nephrectomy is contraindicated in the following cases:
1. Lymphadenopathy.
2. Inferior vena cava involvement.
3. Extensive perinephric visceral involvement.

## 24.3 Preoperative Evaluation

Preoperative imaging should provide the surgeon with the following information:
1. Position of the kidney relative to the lower rib cage, spine, and iliac crest.
2. Tumor location and depth of tumor extension into the kidney.
3. Relationship of the tumor to the collecting system as well as the renal arterial and venous anatomy, especially the segmental arterial supply to the tumor.

The diagnosis of RCC is generally made by CT with intravenous injection of contrast, showing a solid mass in the parenchyma of the kidney. Fewer than 5% of all RCC have a cystic appearance with separations, irregular borders, dystrophic calcification, or other features that distinguish it from a simple renal cyst.

The differential diagnosis of the solid kidney masses include: oncocytoma (granular oncocytes on histological analysis, with a central scar in the tumor); angiomyolipoma (contains fat, seen on CT scans); xanthogranulomatous pyelonephritis (usually in patients with diabetes, with a concurrent stone in a poorly functioning kidney); fibromas; or metastasis.

Both CT and MR imaging are used to stage renal tumors. Abdominal CT is useful to show local extension of the tumor and presence of enlarged para-aortic lymph nodes. Spiral CT should be done if extensive parenchymal resection is planned to detect polar arteries and to evaluate extension of the tumor in the renal sinus and veins (Coll et al. 1999). These new imaging studies have replaced, to a large extent, venocavography and arteriography, which are more invasive. Chest radiograph or CT is routinely done to rule out pulmonary metastasis. Bone scan is required only in the presence of a large tumor or if clinical evaluation suggests skeletal metastasis.

When evaluating renal tumors, the urologist is looking for certain information to help in constructing a management plan. Here are some of the points that contribute to the surgical decision-making.

### 24.3.1 Is It a Tumor or a Pseudotumor?

Pseudotumors in the kidneys are rare; however, this diagnosis should be taken into consideration. A hypertrophied column of Bertin, inflammatory renal mass, or perinephric inflammation extending to the kidney may be confused with a renal tumor. A CT scan is usually very helpful in delineating the nature of the tumors. In some cases, when the nature of these masses is undetermined, a repeat CT a few weeks later shows a significant change in an inflammatory mass, whereas a tumor change is less remarkable. A hypertrophied column of Bertin has been a diagnostic problem on the intravenous pyelogram and a dimercaptosuccinic acid (DMSA) nuclear scan is required to establish the diagnosis. A column of Bertin is homogenous with the rest of the kidney tissue, whereas a tumor shows different isotope uptake. Most of these swellings, however, can be differentiated with a CT scan which obviates the need for a nuclear scan (Mazer and Quaife 1979; Thornbury et al. 1980).

### 24.3.2 Is It a Cystic Tumor?

Cystic renal masses range from a simple cyst to cystic renal carcinoma. Characterization of cystic renal masses relies mainly on the Bosniak classification, which consists of four categories (Bosniak 1986; Bosniak 1991; Bosniak 1994): benign simple cysts (category I); minimally complicated cysts (category II); indeterminate cystic renal masses that include cystic renal tumors (multiloculated or not) and complex cysts (category III); and cystic renal carcinomas (category IV). Usually, category I cysts are not an indication for surgery unless they are symptomatic, category II are most likely benign and can be watched, category III are more likely to be malignant, and category IV are highly suspicious for being malignant (Bosniak 1997; Koga et al. 2000).

### 24.3.3 Is It a Solid Tumor?

In general, a solid tumor should be considered malignant until proved otherwise, with the exception of a tumor that contains fat on the CT scan (angiomyolipoma) or tumors that do not enhance on a CT and do not grow on follow-up CT exams. Oncocytoma is another tumor that is difficult to differentiate from malignant tumors radiologically and is usually diagnosed after excision (Schatz and Lieber 2003).

Surgical planning is usually dependent on radiological information. The extent of the tumor and its location in the kidney, proximity to the renal collecting system and renal vessels, and presence of fat planes between the tumor and other structures (e.g., liver, colon, posterior abdominal wall muscles) are all important information in helping the surgeon to assess the local invasiveness of the tumor.

### 24.3.4 Role of Intraoperative Ultrasound in Partial Nephrectomy

Ultrasound has emerged as a useful modality for intraoperative evaluation during LPN (Assimos et al. 1991). In general, the kidney and associated lesions are best imaged with a 7.5-MHz probe, which is especially useful in identifying the extent of lesion depth within the parenchyma. Excellent anatomical resolution can be attained using probes of higher frequency applied to the kidney surface directly (Fig. 24.1). Since US is a dynamic study, it is equipped to identify the boundary of the surgical margin in real-time. It can also provide intraoperative detail in evaluating complicated cysts (Figs. 24.2, 24.3). Duplex Doppler scanning is useful in assessing tumor vascularity and can help in differentiating a cyst or dilated calyx from an artery or vein. The renal vein and inferior vena cava (IVC) can easily be examined for tumor thrombus. Color Doppler can also identify deep vessels near the wall of the lesion that may be encountered during excision. The identification of these surrounding vessels a few millimeters from a hilar renal tumor may assist the surgeon planning the enucleation of a tumor in this location and can influence the decision to use cold renal ischemia.

Ultrasound has several limitations. It is unable to identify very small lesions, especially if they share a similar echo pattern with the renal parenchyma. Satellite lesions can be also missed, additionally, US

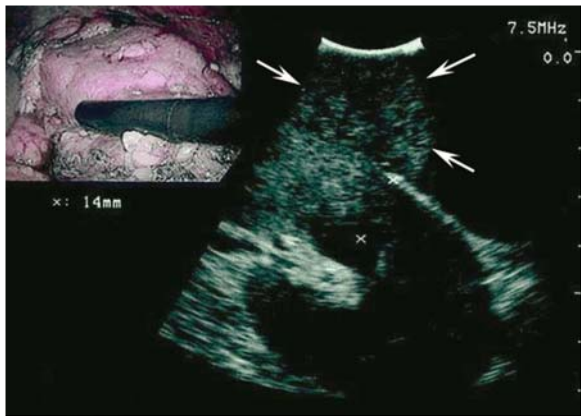



**Fig. 24.1.** Laparoscopic intraoperative real-time ultrasound. Intraoperative US image shows the tumor outlined by *arrows* and 14-mm distance of inner margin of tumor from caliceal system marked by two cursors (*x*). *Inset* shows picture-in-picture capability that allows visualization of location of laparoscope probe on tumorous kidney.

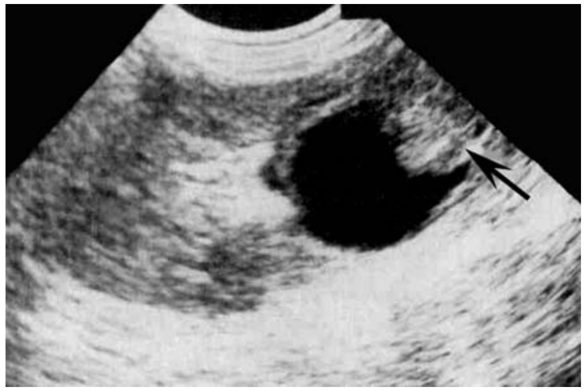
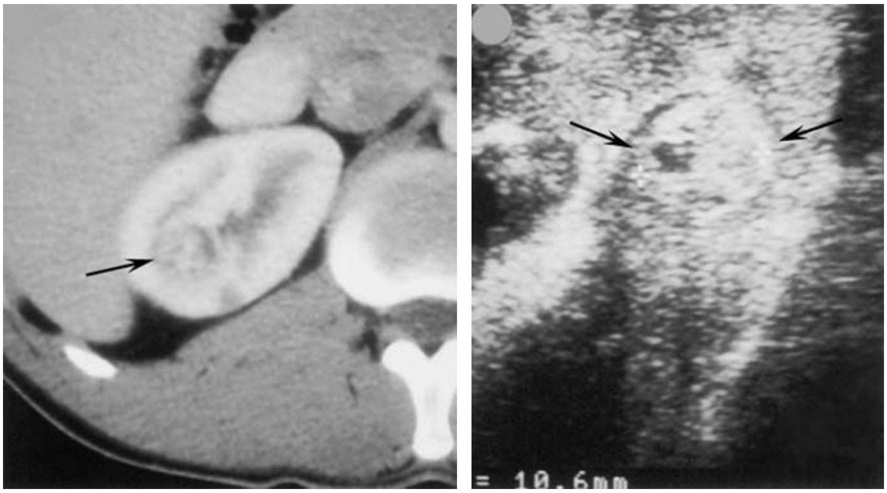


**Fig. 24.2.** Intraoperative real-time ultrasound. Transverse intraoperative US image shows renal tumor (*arrow*) within renal cyst.




a b

**Fig. 24.3a,b.** Solid renal mass. **a** Preoperative axial contrast-enhanced CT scan demonstrates a poorly defined mass (*arrow*) deep in surface of right kidney. **b** Intraoperative US image reveal 1-cm solid lesion (*arrows*) with small cystic components. Small lesion seen on CT on renal surface was fulgurated.

cannot diagnose with certainty whether a particular lesion is benign or malignant. Finally, imaging the adrenal gland is difficult, even with tumor present. The adrenal gland size, shape, anatomical position, and echo pattern are not ideal for US evaluation.

## 24.4 Full Laparoscopic Partial Nephrectomy Techniques

Based on the tumor location, a transperitoneal or retroperitoneal approach can be employed. Tumors on the anterior surface of the kidney are better accessed through a transperitoneal technique, whereas posterior tumors can be accessed with a retroperitoneal technique. In general, the surgeon should choose the approach with which he or she is most experienced. The transperitoneal approach has the advantage of providing a larger space which makes it easier to perform intracorporal sutures. The retroperitoneal approach provides posterior access to the kidney in addition to limiting the dissection to the retroperitoneal space. In cases where urine leaks occur, the leak is limited to the retroperitoneum avoiding peritonitis.

### 24.4.1 Cystoscopy Stent Placement and Positioning

The patient is given general anesthesia and positioned in a lithotomy position. A cystoscopy is performed and a ureteral catheter is inserted in the corresponding ureter. Fluoroscopy is useful in confirming the position of the ureteral catheter in the ureter. Care should be taken to avoid perforating the collecting system with the guide wire or the ureteral catheter; therefore, we prefer to advance the ureteral catheter only half way in the ureter. A Foley catheter is inserted separately into the bladder and the ureteral catheter is tied or taped to it to avoid inadvertent displacement of the ureteral catheter. The ureteral catheter is then connected to a urine bag and is used to inject a diluted methylene blue solution to check for urinary leaks after excising the tumor. Exophytic tumors which are shown to be distant from the collecting system could be excised without stenting the ureter or checking for leaks, however, the authors prefer to insert the stent and check for leaks in every case. In our experience, this is the safest technique to avoid the serious complication of urine leakage.

The patient is then positioned in the lumbar position according to the side of the tumor. We prefer to put the patient in 45° lumbar position for a transperitoneal approach and 90° lumbar position for a retroperitoneal approach.

### 24.4.2 Transperitoneal Approach

We usually use four trocars for the transperitoneal approach; 10 mm at the umbilicus for the laparoscope, 12 mm at the ipsilateral iliac region for dissection and for admission of large instruments, 5 mm in the subcostal region for dissection, and a final 5-mm trocar in the anterior axillary line for the assistant to use for suction, retraction, or to follow the sutures.

After positioning, scrubbing the abdomen from mid-chest to upper thighs, sterile drapes are applied. The surgeon should keep the flank within the surgical field to allow conversion to open surgery in case of an emergency.

The procedure starts with insufflation. It is important to learn the insufflation technique and apply it properly because it is a blind step and can result in many complications. We use a laparoscopic insufflation needle (Veress needle) to start insufflation in the ipsilateral iliac region. In our experience this area is the most successful site for insufflation needle insertion unless the patient has a previous scar in that area. The skin is cut to about 1 cm at the site of the expected trocar, the fat is separated with a hemostat, and the insufflation needle is filled with saline and inserted. The needle should be handled with the surgeon's two hands. One hand applies pressure and the other hand holds the needle close to the skin to control the depth of insertion. The needle should pass two resistances: at external oblique aponeurosis and at the peritoneum. After insertion of the needle in the peritoneum, the valve should be opened to allow the saline in the needle to drop into the peritoneum by the intraperitoneal negative pressure. A 10-ml syringe filled with 5 ml saline is then used to aspirate from the insufflation needle looking for blood or bowel contents. If that test is negative, the saline should be injected and aspirated again to confirm that the needle is not in a blood vessel or bowel. The needle is held in place and insufflation starts with $CO_2$ with a low flow. The resting intraperitoneal pressure should be 4–6 mm Hg. Insufflation continues until 500 ml of $CO_2$ are injected in the peritoneum without a sharp rise in the abdominal pressure or uneven distention of the abdominal cavity. The flow is then increased until the peritoneal pressure reaches 15 mm Hg. The insufflation needle is then removed and the first trocar is inserted in its place. We prefer using trocars with non-cutting tips (unbladed introducers). The camera is then introduced to inspect for injures or bleeding and the insufflation is then continued through the trocar side channel.

Because insufflation is a blind step, it is more likely to result in complications; therefore, careful attention to detail is very important. The insufflation needle should be checked by the surgeon before insertion for any blockages that will give false high pressures. It should be also checked for leaks between the valve and the needle that will leak the saline and give a false saline positive test. If two resistances are not palpated by the surgeon after inserting the needle for appropriate distance, the surgeon should resist advancing the needle further. The needle should be removed, checked, and inserted again. If the pressures at the beginning of insufflation are high or rising quickly, the insufflation should be stopped and the needle removed. However, the surgeon must keep in mind that in obese patients and in very muscular patients, the intra-abdominal resting pressure can be high (10–12 mm Hg); therefore, rising pressure is more alarming than resting pressure during the initial insufflation. Most importantly, if the insufflation is not proceeding well in one area, the surgeon should try another area, e.g., periumbilical or subcostal areas.

Some surgeons prefer to avoid blind insufflation and insert the first trocar under vision through a small incision. If this is preferred, a special trocar with an inflatable cuff at the tip (Hasson trocar) should be used to avoid $CO_2$ from the incision. The rest of the trocars are inserted under vision using the laparoscope. It is helpful to point the laparoscope at the site of the trocar insertion and transilluminate the abdominal wall to avoid injuring the abdominal wall vessels during trocar insertion.

#### 24.4.2.1 Dissection of the Left Kidney

The dissection of the left kidney starts with colon mobilization. An incision is made at Toldt's line from the splenic flexure to the pelvis. The colon should be completely mobilized with its mesentery to avoid colonic injury. There is a relatively avascular plane between the mesentery and Gerota's fascia covering the kidney. Excessive bleeding usually indicates that the dissection is in the wrong plane. We prefer using the laparoscopic ultrasonic shears for this purpose because they cut with mechanical friction, thus avoiding dispersing an electric current close to the colon which might cause electric burns.

The next step is usually to identify the psoas muscle below the lower pole of the kidney, then to identify the ureter and gonadal vein and follow them to the lower pole of the kidney (Fig. 24.4). There is usually a thick layer of fat between the lower pole of the kidney and the mesentery which can be divided safely as long as the ureter is protected and a con-

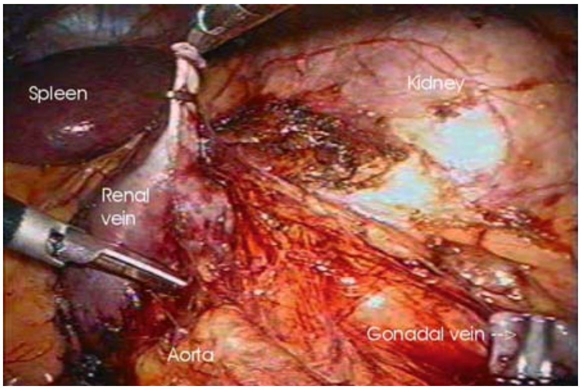



**Fig. 24.4.** Laparoscopic view during laparoscopic partial nephrectomy. The colon has been mobilized and the gonadal vein has been clipped and divided. The fibro-lymphatic tissue lateral to the aorta is being divided by ultrasonic laparoscopic shears.

tinuous watch is maintained for accessory arteries to the lower pole of the kidney. The gonadal vein is then followed to the renal vein which is then carefully dissected. The gonadal vein is either clipped or cauterized with a bipolar current and is divided close the renal vein. The fascia on the lateral aspect of the aortic wall is usually the easiest guide for finding the renal artery. This fascia is usually dissected with a laparoscopic J hook until the white wall of the aorta is identified. The dissection then continues behind the renal vein looking for the pulsations of the renal artery which is then dissected free from its fascia. The space between the renal artery and vein is then developed with a laparoscopic dissector.

Failure to identify the anatomical landmarks is the main reason for complications. While dissecting the colon and mesentery, the surgeon should identify the plane between these structures to avoid penetrating the mesentery or violating the Gerota's fascia. Incisions in the Gerota's fascia on top of the tumor risk contaminating the abdominal cavity with tumor cells. In addition, mobilizing the spleen gives better access to the upper pole of the kidney and helps to keep the colon and pancreas retracted from the renal hilum area.

It is important to identify the ureter after mobilization of the colon. The ureter is usually easily identifiable in front of the psoas muscle below the kidney. Identifying the ureter assists in mobilizing the lower pole and avoids ureteric injury. The surgeon should also be attentive to vasculature in the lower pole area since an accessory lower pole vessel is not unusual. While dissecting the renal pedicle the surgeon should be alert to vascular anatomy variations particularly with the venous system. Lumbar veins should be assumed present until proven otherwise. If these veins are injured, they retract into the muscle and become hard to control. They are also close to the main renal vessels and trying to control them in the midst of bleeding can result in damaging these structures. Some patients will have a retro-aortic vein diagnosed by radiological investigations before surgery. In our experience neither retro-aortic veins nor multiple renal arteries are contraindications for laparoscopic surgery.

### 24.4.2.2 Dissection of the Right Kidney

The dissection of the right kidney usually starts with retracting the liver through a 5-mm trocar inserted in the midline under the xiphisternum. A laparoscopic locking grasping forceps should be passed under the falciform ligament to retract it with the liver and gallbladder and is then used to grasp the peritoneum on the lateral abdominal wall as high as possible. The right colon is then mobilized from in front of the kidney with ultrasonic scissors and the peritoneum between the kidney and the under surface of the liver is divided. The duodenum should be identified and mobilized medially. Care should be taken not to use electric cauterization close to the duodenum because it can cause thermal damage. The IVC is then identified and the gonadal vein is found. The ureter is usually easily identified lateral to the IVC below the kidney. In most patients the gonadal vein can be left intact. The renal vein is then identified and dissected carefully. The adrenal gland is also identified, but it should only be mobilized in patients with upper-pole renal tumors. The renal artery is usually found behind the renal vein on the lower side. The space between the vein and artery is dissected with a laparoscopic dissecting forceps. In some patients the artery is located on the upper side of the vein. In these circumstances it is better to mobilize the kidney completely and access the artery behind the kidney since anterior approach risks bleeding from the renal or adrenal veins that are located in that area.

The right kidney is usually easier to dissect than the left kidney. Retracting the liver at the beginning of the procedure is very important to gain access to the kidney's upper pole and avoid injuries to the liver and gallbladder. When the adrenal gland is to be dissected from the upper pole of the kidney, the surgeon should be very careful about the venous anatomy in this area. Some patients have very small veins between the adrenal gland and the renal vein that can be a source of significant bleeding. Similar to the left kidney, dissecting the right ureter early avoids its injury. The gonadal vein could be preserved in most patients; however, if it obstructs the view to the ureter or renal artery, it should be sacrificed early in the dissection to avoid its avulsion. We prefer using the bipolar coagulation to control the gonadal vein. In some patients the duodenum will look similar to the IVC at the beginning of the dissection. In other patients the duodenum is located medially and the IVC is the first structure behind the colon. Nevertheless, the structure first found behind the colon should be treated as the duodenum until the duodenum is clearly identified. Sticking to this policy helps in avoiding inadvertent duodenal injuries due to mistaking it for the IVC.

### 24.4.2.3 Identifying the Tumor and Planning the Excision

We prefer to locate the tumor with laparoscopic US in every case. This technique allows mapping of the excision margins. The fat on top of the tumor should be excised and sent for permanent histological study for cancer staging. Using the laparoscopic US probe on the surface of the kidney, small cauterization marks should be made on the surface of the kidney about 5 mm away from the tumor to provide safety margins. The depth of the tumor and its proximity to the renal collecting system should be also noted on the US images.

#### *24.4.2.3.1 Clamping the Vessels and Excising the Tumor*

Although small exophytic tumors may be enucleated without arterial clamping, most partial nephrectomies require clamping of the renal artery before excising the tumor. The kidney can sustain 30–40 min of warm time ischemia without permanent damage. Before clamping the vessels, the surgeon should prepare and check all necessary tools that are needed for excising the tumor, check the collecting system for leaks, repair the collecting system when necessary, and provide hemostasis to the renal surface. We usually prepare laparoscopic bulldog clamps, Surgicel, 5° and 0 Vicryl sutures, diluted methylene blue, and SurgiFoam (Johnson & Johnson) loaded in a 10-ml syringe, and a laparoscopic applicator for the SurgiFoam.

The patient is given 12.5 g of intravenous Mannitol a few minutes before clamping the vessels to improve the renal flow and reduce the effect of oxygen radicals after unclamping. The renal artery is temporarily occluded with a bulldog clamp. We prefer to occlude the vein with a separate clamp to reduce the back bleeding from the kidney surface (Fig. 24.5). The tumor with a rim of normal renal tissue is then excised under vision with laparoscopic scissors at the previously marked areas. The assistant should use suction to aspirate the blood leaking from the surface of the kidney to allow cutting under vision. This technique obviates cutting into the tumor and positive margins. The tumor is positioned behind the kidney in a visible area until it is extracted at the end of the procedure. Small biopsies are then excised from the kidney tissue at the tumor bed and are sent for frozen sections to rule out positive margins. The surgeon should continue to repair the kidney surface while waiting on the frozen sections.

The assistant injects 3–4 ml of the diluted methylene blue in the ureteric stent to check for leaks from the collecting system. If a leak exists, the collecting system should be repaired carefully with the 5° sutures until it is water tight (Fig. 24.6). The Flowcel is then applied to the tumor bed and covered with a Surgicel bolster (Ethicon). The edges of the tumor bed are then approximated tightly with the 0 Vicryl sutures (Fig. 24.7). We prefer to use Lapra-Ty clips (Ethicon) to secure the stitches and to apply tension to the kidney surface. They are quicker to use and less likely to cut through the kidney tissue than sur-

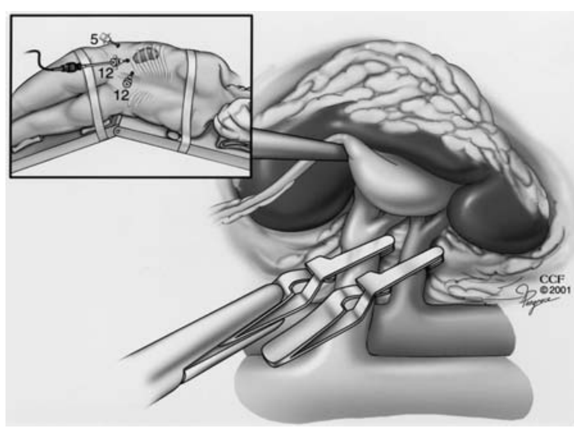



**Fig. 24.5.** Drawing showing clamping of the vessels during retroperitoneal laparoscopic partial nephrectomy. Because of limited operative space in the retroperitoneum, two laparoscopic bulldog clamps were used for individual control of the mobilized renal artery and vein instead of Satinsky clamps. *Inset* shows three-port retroperitoneal approach.

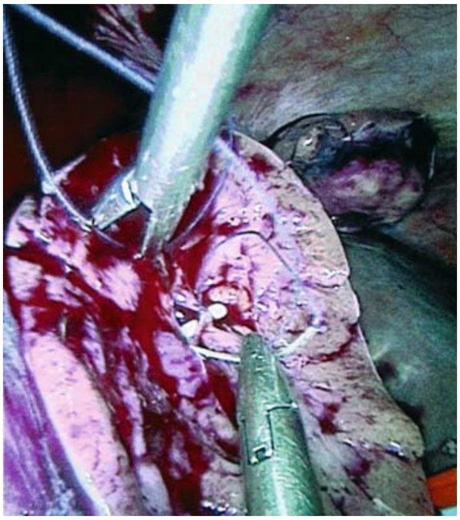


**Fig. 24.6.** Collecting system closure after tumor resection. Collecting system is identified by saline outflow and closed accurately with interrupted absorbable sutures.

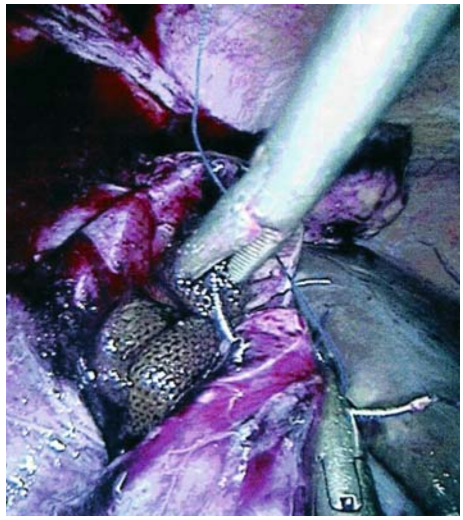


**Fig. 24.7.** Edges of renal parenchyma closure after tumor resection. Edges of renal parenchyma are approximated with absorbable sutures over hemostatic mesh.

gical knots. The vein is then unclamped followed by the artery. The kidney surface is observed carefully for bleeding. If bleeding occurs, extra sutures might be necessary.

#### *24.4.2.3.2 Possible Surgical Complications*

The surgeon should try to keep warm-time ischemia to the minimum in all cases. This is achieved by preparing the tools and materials in advance and by planning the excision before clamping. The excision of the tumor should be performed under vision to avoid cutting into it. The renal collecting system should be checked with a methylene blue injection since visual inspection is not reliable and could result in neglecting a perforation in the collecting system and a urine leak.

Some surgeons report using fibrin glues or other similar substances to control bleeding from the collecting system. In our experience, applying Flowcel to the tumor bed with Surgicel bolsters and tension sutures is the most reliable and reproducible technique for hemostasis. If bleeding from the renal surface continues after unclamping the vessels, more tension sutures should be taken in the tumor bed edges until hemostasis is secured.

Manipulation of the renal artery with the bulldog clamp should be gentle to avoid damage to the arterial wall. If the artery goes into spasm, applying a papaverine solution to the arterial wall using the cleaned SurgiFoam injector is usually helpful.

If the frozen sections are positive for tumor, a decision should be made to re-clamp the vessels and excise more of the kidney tissue, versus performing radical nephrectomy. Re-clamping the vessels carries more risk for permanent renal damage, however, in patients with impaired total renal function, partial nephrectomy is preferred.

### 24.4.3 Retroperitoneal Approach

For the retroperitoneal approach, the patient is usually positioned in a 90° flank position. An incision is made in the mid-axillary line under the costal margin long enough to admit the surgeon's index finger. The fat is separated and the abdominal wall fascia and muscles are perforated with the tip of a hemostat. The surgeon's finger is then admitted into the wound to palpate the retroperitoneal fat under the muscles. The insufflating trocar with an oval balloon at its tip is introduced with the laparoscope inserted in the port to allow insufflation of the retroperitoneum under vision. The retroperitoneal space is developed with the balloon and the balloon is kept inflated for 3 min to improve hemostasis. The port is then removed and a working port with a retention balloon is introduced (Hasson port). The retroperitoneum is then insufflated directly with $CO_2$ to a pressure of 15 mm Hg. A second 5-mm trocar is inserted under vision in the posterior axillary line. The fat and bowels are dissected with blunt dissection from the back of the abdominal muscles. A Kittner dissector is usually good for that purpose; if one is not available, the tip of the suction tube could be used. A third, 12-mm trocar is inserted medially in the anterior axillary line. The dissection should continue behind the kidney in front of the psoas muscle. The ureter is usually identified easily. The dissection continues cephalad looking for the artery. In most patients the pulsations of the renal artery are visible and the artery is dissected free. The renal vein is then displayed in front of the artery. The rest of the procedure is continued as in transperitoneal laparoscopy.

The patient selection for this approach is important. Patients with a significant amount of retroperitoneal fat and those with a short stature or back problems present difficulties for this procedure. The surgeon should be sure that the initial incision is through the abdominal fascia and his finger can feel the retroperitoneal fat before developing the space; otherwise, the developed space will be in the wrong level and the operation will become more complicated.

After insufflation, the iliopsoas muscle is an excellent landmark for the ureter and the renal hilum. Before inserting the medial port in the anterior axillary line, the surgeon should be sure to mobilize the fat completely to see the muscle fibers of the transversus abdominis muscle. Failure to do so risks transfixing the colon with the trocar, an injury that, if unnoticed, could result in serious consequences.

## 24.5 Hand-Assisted Laparoscopic Partial Nephrectomy

With a hand in the abdomen, it is easier to make the transition from traditional open surgery to laparoscopy. Hand-assisted laparoscopy provides more safety and security to the surgeon and patient. There are many commercially available hand ports. We prefer using the Gellport (Applied Medical) over other products because of its ease of use and lack of air leaks. The ideal hand port does not yet exist and we hope that better products become available.

This procedure is performed through a 6- to 8-cm incision in the midline where the surgeon's non-dominant hand is inserted in the abdomen to assist in the dissection. The position of the incision should be centered around the umbilicus in most patients; however, in large patients a paramedian incision and laterally placed port incisions are more suitable. Some surgeons prefer to insert the hand port incision in the ipsilateral iliac region. It is important when fitting the hand port to make sure that none of the abdominal contents are trapped under the port collar. The abdomen should be insufflated with $CO_2$ and the camera should be introduced into the hand port to inspect the abdomen before placing the instrument ports. Three laparoscopic ports are inserted: 10 mm for the camera; 12 mm for large instruments; and 5 mm for assistance. On the right side, another 5-mm port under the xiphisternum is useful for liver retraction as mentioned above. The dissection should be continued as in full laparoscopy; however, having a hand in the abdomen allows for palpation and more flexibility in handling the tissues.

Hand-assisted laparoscopy has the advantages of a short learning curve and shorter operative time; however, most LPN can be performed with full laparoscopy where the tumor is extracted through a 2- to 3-cm incision, thus avoiding the 8-cm incision for hand-assisted surgery.

## 24.6 Challenges in Laparoscopic Partial Nephrectomy

Laparoscopic partial nephrectomy has proved to be a challenging technique for most urologists. Urinary leaks from the injured collecting system and difficulty achieving hemostasis from the renal surface are the two most common challenges. Water-tight sutures of the renal collecting system have proved to be the most reliable way of avoiding a urinary leak. The insertion of a ureteric catheter and injection of indigo carmine in the kidney identifies any urinary leak from the collecting system that needs to be sutured until completely sealed off.

Reliable hemostasis of the cut renal surface presents a challenge to the surgeon. The kidney is a highly vascular organ that receives half a liter of blood per minute. Several hemostatic techniques have been tried in LPN; these include the use of monopolar and bipolar electric coagulation, radiofrequency energy, laparoscopic harmonic scissors, fibrin glue, gelatin resorcinol formaldehyde glue, microwave coagulation, and laparoscopic sutures. The effectiveness of these techniques is not universally agreed upon. In our experience inserting compressing sutures that approximate the cut edges of the kidney on a Surgicel bolster is the most reproducible hemostatic technique. Table 24.1 summarizes some of the published results for LPN.

## 24.7 Results

The initial 50 patients undergoing laparoscopic partial nephrectomy at the Cleveland Clinic had a mean tumor size of 3 cm (1.7–7 cm), mean warm-ischemic time of 23 min, mean estimated blood loss of 270 ml, mean operative time of 3 h, and a median length of hospital stay of 2.2 days (Gill et al. 2002). Recently, the initial 200 patients undergoing laparoscopic partial nephrectomy were compared with a contemporary cohort of patients undergoing open NSS (Gill et al. 2003). The median tumor size was 2.8 cm in the laparoscopic group compared with 3.3 cm in the open group ($p$=0.005). When comparing the laparoscopic to open groups, the median surgical time was 3 vs 3.9 h ($p$<0.001), the estimated blood loss was 125 vs 250 ml ($p$=0.001), and the mean warm-ischemic time was 28 vs 18 min ($p$=0.001). The laparoscopic group required less postoperative analgesia and experienced a shorter hospital stay and a shorter period of convalescence ($p$<0.001 for all three comparisons). Although there were more intraoperative complications in the laparoscopic group (5% vs 0), the frequency of postoperative complications was similar (9 vs 14%; $p$=0.27). The specific complications occurring in the laparoscopic group are detailed in Table 24.2. There were three positive surgical margins in the laparoscopic group and none in the open group. One of these patients had an oncocytoma and the other two had renal cell carcinoma. At 2- and 3-year follow-up, both patients remained free of disease.

Kim et al. (2003) recently compared complications related to LPN and laparoscopic radical nephrectomy for tumors <4.5 cm at Johns Hopkins medical institution. Laparoscopic partial nephrectomy is associated with specific complications such as urine leak, pseudoaneurysm formation, and delayed hemorrhage. In the group of patients undergoing laparoscopic partial nephrectomy ($n$=79), mean surgical time was 181.9 min, mean warm-ischemic time 26.4 min (range 13–37 min), and the mean estimated blood loss was 391.2 ml with 4 patients (5.1%) requiring transfusion and one conversion to open surgery for bleeding problems. Specific complications included one ureteral injury managed laparoscopically, and persistent urine leak in 2 patients that resolved with conservative measures. Surgical margins were reported to be positive in 2 patients postoperatively, of whom 1 underwent laparoscopic radical nephrectomy while the other has remained free of disease after 26 months of follow-up. Table 24.3 summarizes some of the published results of LPN.

**Table 24.1.** Clinical laparoscopic partial nephrectomy series. *US* ultrasound, *RF* radiofrequency, *NR* not reported

| Reference | Technique | Hemostasis | No. of patients | Mean tumor size (cm) | Positive margin | Tumor recurrence | Mean follow-up (months) |
|---|---|---|---|---|---|---|---|
| Gill et al. (2002) | Full laparoscopy | | 50 | 3.0 | 0 | 0 | 7.2 |
| Stifelman et al. (2001) | Hand-assisted | | 11 | 1.9 | 0 | 0 | 8.0 |
| Harmon et al. (2000) | | US shears | 15 | 2.3 | 0 | 0 | 8.0 |
| Gettman et al. (2001) | | RF coagulation | 10 | 2.1 | 0 | NR | NR |
| Yoshimura et al. (2001) | | Microwave tissue coagulator | 6 | 1.8 | 1 | 0 | 3.0 |

**Table 24.2.** Complications of laparoscopic partial nephrectomy ($n$=100)

| Intraoperative complications ($n$=5) | Postoperative complications ($n$=9) | Late complications ($n$=16) |
|---|---|---|
| Bleeding (3) | Urine leak (3) | Delayed nephrectomy (1) |
| Bowel injury (1) | Pneumonia (1) | Wound infection (2) |
| Resected ureter (1) | Atelectasis (3) | Hematuria (1) |
| Convert to open surgery (0) | Arrhythmia (2) | Severe constipation (hospitalized) (1) |
| | | Embolization (1) |
| | | Chronic heart failure (hospitalized) (1) |
| | | Wound dehiscence (1) |
| | | Urine leak (1) |
| | | Hematoma (1) |
| | | Incisional hernia (1) |
| | | Pneumonia after discharge (3) |
| | | Pulmonary embolus/deep (1) |
| | | Vein thrombosis (1) |

**Table 24.3.** Published series of laparoscopic partial nephrectomy with at least ten patients treated

| Reference | No. of patients | Mean tumor size (cm) | Hilar control | No. of pelvicalyceal repairs |
|---|---|---|---|---|
| Janetschek et al. (2000) | 25 | 1.9 | No | 0 |
| Harmon et al. (2000) | 15 | 2.3 | No | 3 |
| Rassweiler et al. (2000) | 53 | 2.3 | – | – |
| Gill et al. (2003) | 100 | 2.8 | Yes (91) | 64 |
| Guillonneau et al. (2003) | 28 | 1.9 | No (12) | 0 |
| | | 2.5 | Yes (16) | – |
| Kim et al. (2003) | 79 | 2.5 | Yes (52) | – |
| Simon et al. (2003) | 19 | 2.1 | No | 0 |

## 24.8 Conclusion

Laparoscopic partial nephrectomy is emerging as an attractive, minimally invasive nephron-sparing option for the management of select renal lesions. It is associated with less need for postoperative analgesia, earlier hospital discharge, and more rapid convalescence. Experience with LPN continues to grow. The technique is evolving and issues of hemostasis and renal ischemia are being further addressed in the laboratory. It should be performed by surgeons with considerable laparoscopic expertise at centers where there is frequent interaction between open and laparoscopic surgeons.

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