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# 5 Laparoscopic Surgery for Renal Cell Carcinoma

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## LAPAROSCOPIC RADICAL NEPHRECTOMY FOR CANCER

### Introduction

Since Clayman's initial description of laparoscopic nephrectomy, this procedure has rapidly gained worldwide acceptance. At centers where such expertise is available, laparoscopic radical nephrectomy can comfortably be considered a, if not the, standard of care for the appropriate patient with an organ-confined T1 renal tumor. Either the transperitoneal or the retroperitoneal laparoscopic approach can be employed, depending on the individual patient characteristics and, particularly, the training and expertise of the laparoscopic surgeon. Contraindications for laparoscopic radical nephrectomy today include vena caval thrombus, bulky lymphadenopathy, and locally invasive tumors. Large tumor size is only a relative contraindication, dependent on the comfort level of the laparoscopic surgeon and the individual characteristics of the tumor. Although laparoscopic radical nephrectomy for pT2 tumors has been reported, the possibility of significant-sized peritumoral collateral vessels and desmoplastic reaction must be kept in mind. Contraindications include significant cardiopulmonary comorbidity, uncorrected coagulopathy, and abdominal sepsis. Significant prior surgery in the quadrant of interest and morbid obesity increase the level of technical difficulty, although we have had gratifying success in these two challenging circumstances by employing the retroperitoneal laparoscopic approach.

### Patient Preparation and Positioning

Detailed informed patient consent is obtained. Bowel preparation involves two bottles of magnesium citrate self-administered the afternoon prior to surgery. The patient reports to the hospital on the morning of the operation. Intravenous broad-spectrum antibiotics and sequential compression stockings bilaterally are routine. For the

transperitoneal approach, the patient is positioned in a 60° flank position with the kidney bridge mildly elevated and the table mildly flexed. Emphasis is placed on meticulous foam padding of soft tissue and bony sites, including the head and neck, axilla, hip, knee, and ankle, along with careful ergonomically neutral positioning of the neck, arms, and legs. This is important to prevent postoperative neuromuscular strain.

### Port Placement (Fig. 5.1)

We prefer to obtain peritoneal access with the Veress needle (closed) technique. Typically, a four- to five-port approach is employed. The primary 10/12-mm trocar is inserted at the lateral border of the rectus at the level of the umbilicus. Three secondary trocars are placed: a 10/12-mm port for the laparoscope approx 2–3 finger-breadths below the costal margin at the lateral border of the rectus, a 10/12-mm port 2–3 finger-breadths lateral to the rectus muscle at the costal margin, and a 2-mm port for lateral retraction of the kidney at the anterior axillary line. For a left-sided nephrectomy, a 5-mm port is placed at the lateral border of the rectus near the costal margin. For a right-sided nephrectomy, a 5-mm port is inserted near the xiphisternum for retraction of the liver.

### Colon Mobilization

On the right side, the line of Toldt is incised to mobilize the ascending colon medially. This posterior peritoneal incision is carried transversely in a medial direction along the undersurface of the liver up to the vena cava. Blunt dissection mobilizes the ascending colon, hepatic flexure, and the duodenum medially until the anterior aspect of the inferior vena cava is clearly exposed. On the left side, more formal mobilization of the splenic flexure, spleen, and pancreas is necessary because these structures almost completely cover the anterior aspect of Gerota's fascia. As such, comparatively more mobilization of the colon is necessary on the left side compared to the right. The

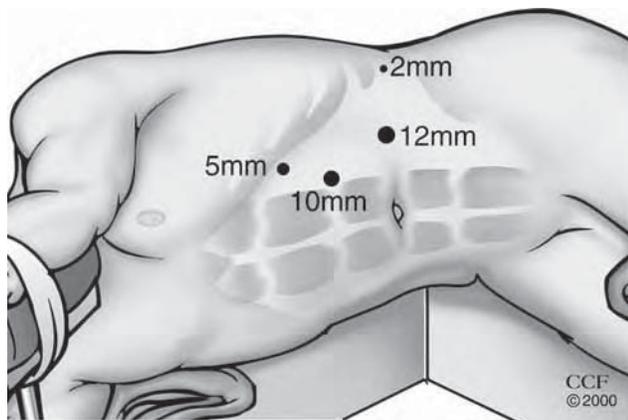


Fig. 5.1

incision along the line of Toldt is more extensive, and the splenocolic, splenorenal, and splenophrenic fascial attachments are released. The spleen is mobilized along its lateral border and is placed medially, where it typically stays by gravity alone. It is important to enter the correct avascular fascial plane between the anterior surface of Gerota's fascia and the posterior aspect of the descending mesocolon, similar to open surgery.

### Renal Hilum Control (Figs. 5.2 and 5.3)

The ureter/gonadal vein packet is identified inferior to the lower pole kidney and just lateral to the ipsilateral great vessel. Psoas muscle is identified by blunt dissection. The ureter and gonadal vein are secured and divided. Taut lateral retraction is placed on the divided ureter/gonadal vein, placing the renal hilum on stretch. Dissection along the psoas muscle and lateral border of the ipsilateral great vessel leads to the renal hilum. Antero-lateral twisting and retraction of the lower pole kidney helps to bring the posteriorly located renal artery into ready view. The renal artery is circumferentially mobilized, clipped, and divided. The renal vein is controlled with an Endo-GIA stapler (US Surgical, Norwalk, CT). A careful search must be made for any secondary renal hilar vessels, which are controlled appropriately with Weck clips.

### Concomitant Adrenalectomy

Typically, concomitant adrenalectomy is indicated if there is any alteration in size, shape, or location of the adrenal gland on preoperative computed tomography (CT) scanning. Additionally, an upper pole tumor physically abutting the adrenal gland mandates concomitant adrenalectomy. The right adrenal vein is a short, stubby vessel directly entering the infrahepatic vena cava from the superomedial aspect of the right adrenal gland. Dissection is performed along the right lateral surface of the inferior vena cava (IVC) to reach the adrenal vein, which is mobilized,

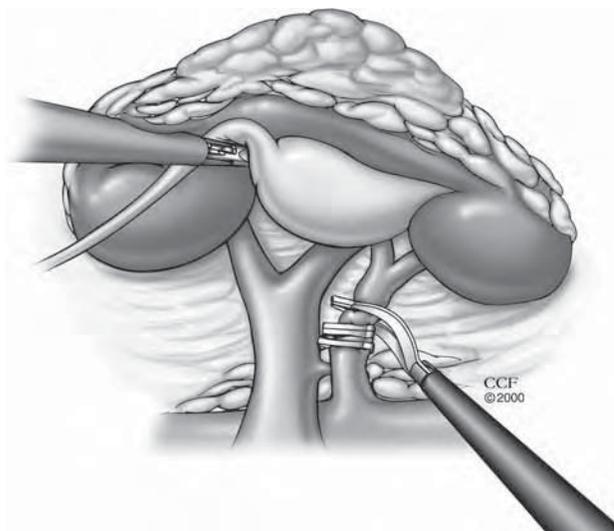


Fig. 5.2

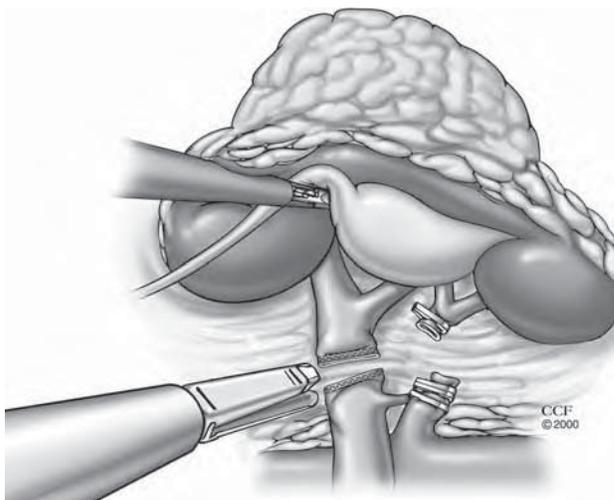


Fig. 5.3

controlled with Weck clips, and divided. On the left side, the longer, narrower main left adrenal vein arises from the inferior medial aspect of the adrenal gland and drains directly into the left renal vein. It is similarly mobilized, clipped, and divided. If concomitant adrenalectomy is indicated, the lateral surface of the ipsilateral great vessel is dissected bare, and all lymphatico-fatty tissue in this area is excised. Care must be taken to clip any suspicious lymphatic channels to avoid postoperative chylous ascites.

### Specimen Entrapment (Fig. 5.4)

We entrap the specimen in an Endo-catch bag (US Surgical, Norwalk, CT) and routinely perform intact extraction through a low Pfannenstiel's incision in the suprapubic area. For this muscle-splitting incision, the skin is incised at the level of the symphysis pubis, and the anterior rectus

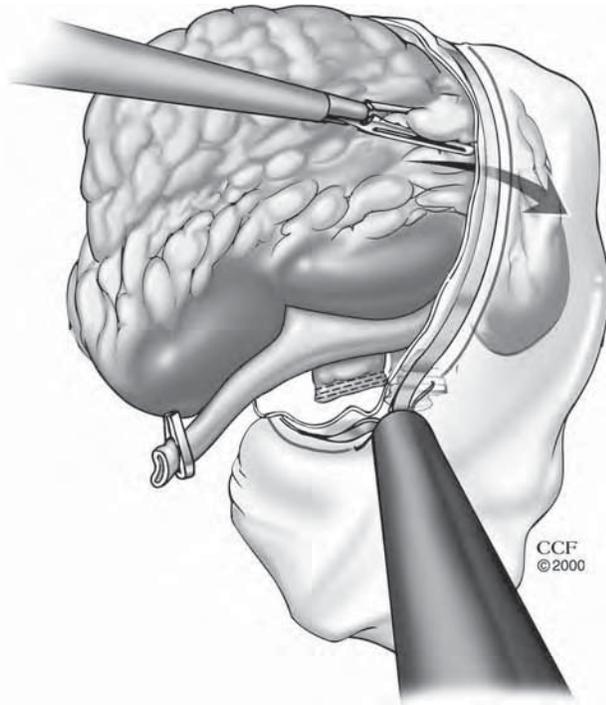


Fig. 5.4

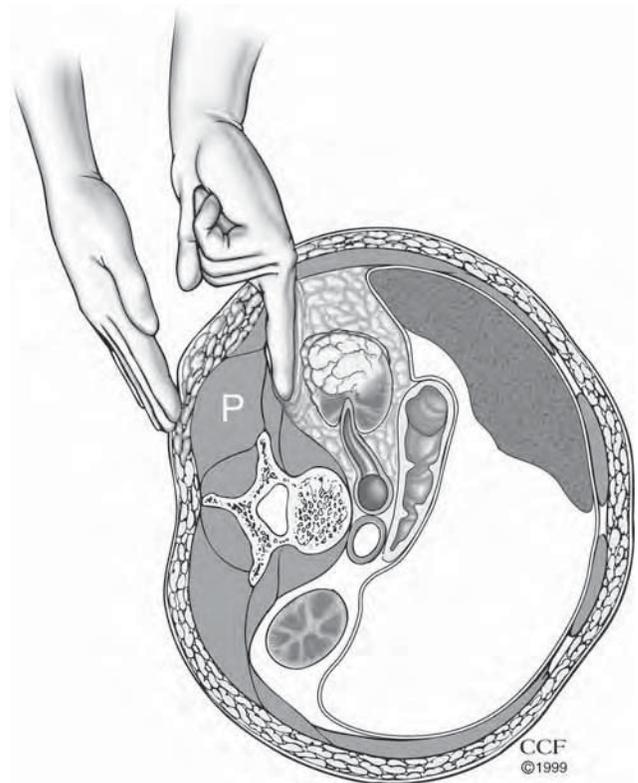


Fig. 5.5

fascia is incised obliquely somewhat higher up, thus achieving a cosmetically preferred extraction incision. The author does not perform morcellation for any cancer.

### Retroperitoneal Approach

The patient is positioned in the standard full-flank position with the kidney rest elevated and the operative table flexed. This maximizes the space between the iliac crest and the lowermost rib. However, care is taken to lower the kidney rest and straighten the operative table as soon as all laparoscopic trocars are inserted. As such, for the majority of the operation, there is virtually no flexion of the operative table.

### Retroperitoneal Access (Fig. 5.5)

The author employs the open Hasson technique. A horizontal skin incision (1.5–2 cm) is made at the tip of the 12th rib. The flank muscle fibers are separated with two S-retractors to visualize the anterior thoracolumbar fascia, which is incised to enter the retroperitoneal space with the tip of the index finger. Digital dissection is performed along the anterior surface of the psoas muscle and fascia, posterior to Gerota's fascia (to create a space for the balloon dilator).

### Balloon Dissection (Fig. 5.6)

The PDB balloon dilator (US Surgical, Norwalk, CT) is inserted into the retroperitoneum. Approximately six to eight pumps of the sphygmomanometer bulb are done to

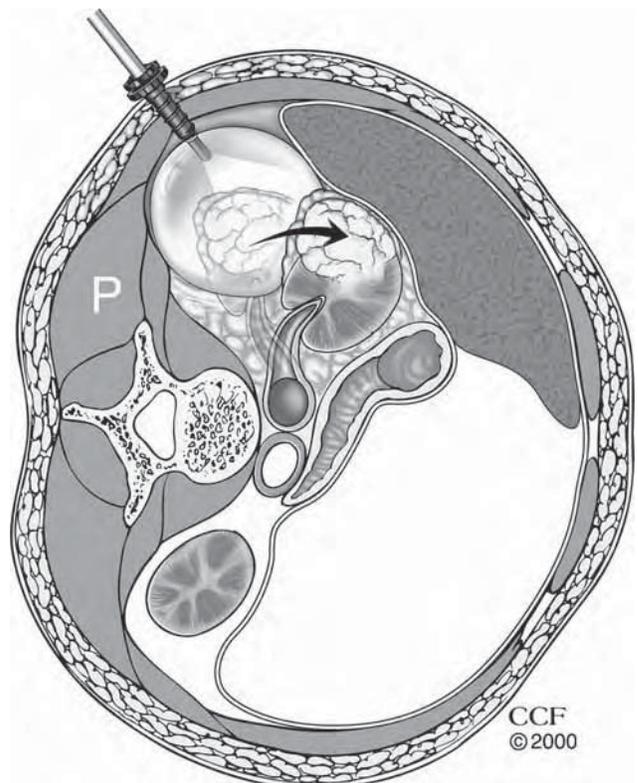


Fig. 5.6

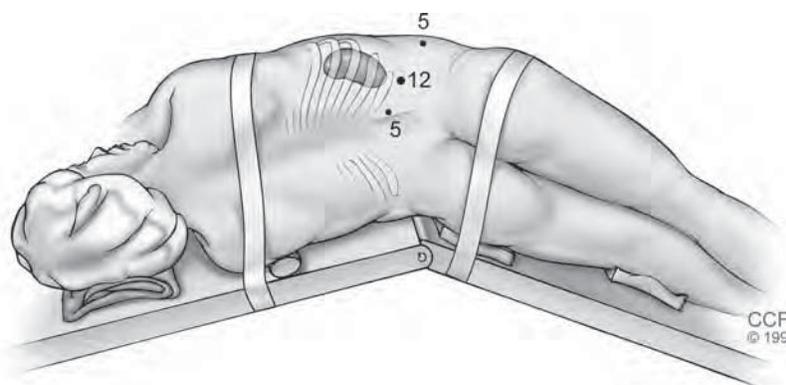


Fig. 5.7

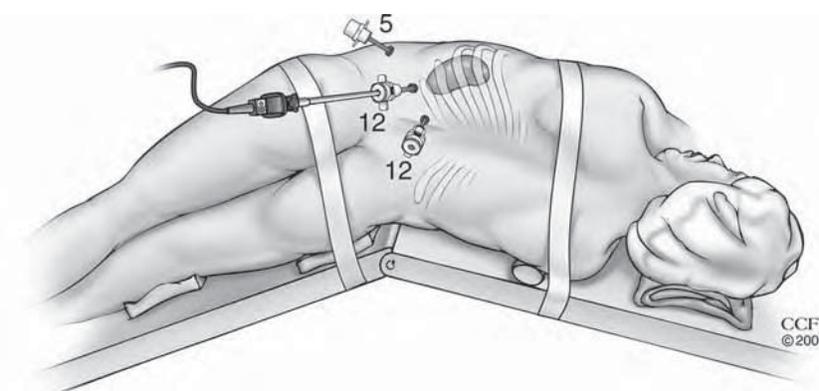


Fig. 5.8

instill approx 150 cc of air in the balloon. The shaft of the balloon dilator is now retracted outward, thereby impacting the balloon against the undersurface of the anterior abdominal wall. An additional 30 pumps of the sphygmomanometer bulb are now performed to create the retroperitoneal space. This maneuver ensures that the entire peritoneal deflection is mobilized medially, without any overhanging peritoneal shelf. In this manner, the *en bloc* kidney and surrounding Gerota's fascia are mobilized medially, thus exposing the posterior aspect of the renal hilum and the adjacent vessels to clear laparoscopic view.

### Port Placement (Figs. 5.7 and 5.8)

After removing the balloon dilator, a 10-mm blunt tip cannula (US Surgical, Norwalk, CT) is inserted as the primary port. Pneumoperitoneum (15 mm) is created and retroperitoneoscopic examination completed. An anterior port (10/12 mm) is placed 3–4 cm cephalad to the iliac crest in the anterior axillary line. A posterior port is placed at the junction of the 12th rib and the spinal muscles. Typically, we employ this standard three-port approach for all retroperitoneoscopic ablative renal and adrenal surgery. All ports are placed under clear laparoscopic visualization.

### Renal Vessel Control

Careful laparoscopic inspection reveals the pulsations of the fat-covered renal artery, which are oriented vertically and are distinct from the transversely located pulsations of the aorta (sharp pulsations) or IVC (gentle undulating pulsations). The psoas muscle must be kept horizontal at all times on the monitor and is the single most important anatomical landmark in the retroperitoneum. It is also important to maintain constant taut anterior retraction of the Gerota's fascia-covered kidney with a three-pronged retractor in the surgeon's nondominant hand inserted through the anterior port. Using the J-hook electrocautery, Gerota's fascia is incised parallel and 1–2 cm anterior to the psoas muscle directly over the renal arterial pulsations. The renal artery is circumferentially mobilized, clipped (three clips toward the aorta, two clips toward the kidney), and divided. The renal vein is usually located anteriorly and somewhat caudal to the renal artery. In a similar manner, this is circumferentially mobilized and controlled with an EndoGIA vascular stapler. Concomitant adrenalectomy is performed in a similar manner as during transperitoneal radical nephrectomy. The ureter and gonadal vein are identified as a last step, clipped, and divided.

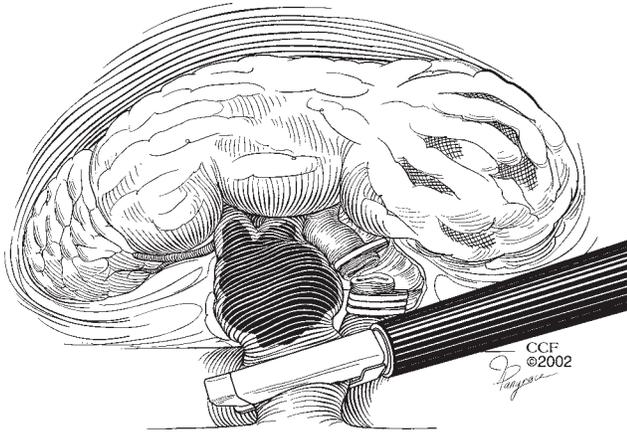


Fig. 5.9

### Renal Vein Thrombus (Fig. 5.9)

Laparoscopic radical nephrectomy for level 1 renal vein thrombus has been described. Intraoperative flexible ultrasonography is performed to specifically reveal the extent of tumor thrombus in the renal vein and make a determination as to the laparoscopic technical feasibility of complete excision and obtaining negative vascular margins. The main renal artery is secured and the renal vein completely mobilized. The proximal renal vein now typically appears flat because it is devoid of blood flow and stands clearly demarcated from the distended distal renal vein, which contains the intraluminal venous thrombus. This is typically clearly visible laparoscopically and is further confirmed by contact color Doppler ultrasonography. Using the EndoGIA stapler, the renal vein is transected proximal to the thrombus.

### Mobilization of Kidney

The inferior pole of the kidney is mobilized from the undersurface of the peritoneum. Caudal traction on the partially mobilized kidney now places the peri-renal fat around the upper renal pole on stretch. The upper pole of the kidney is mobilized from the undersurface of the adrenal gland (in adrenal-sparing nephrectomy) or from the undersurface of the diaphragm (if concomitant adrenalectomy is performed). Finally, the kidney is mobilized from the undersurface of the peritoneal envelope, completely freeing the specimen. Care is taken not to employ any electrocautery along the peritoneal surface of the kidney so as to guard against injury to intraabdominal viscerae or bowel. Remember, although out of sight, bowel loops must never be out of mind because they are separated only by the thin peritoneum, with a real potential for transmural injury.

### Specimen Extraction

The specimen is entrapped in an Endo-catch bag, as in the transperitoneal approach. Again, intact extraction is

performed through a pfannenstiel incision, while staying completely extraperitoneal. Typically, no drain is placed and laparoscopic exit is completed in the usual fashion.

### Postoperative Care

The patient is mobilized on the evening of surgery. Two Dulcolax suppositories are administered on the morning of postoperative day 1. In the majority of our cases, the patient is discharged on the evening of postoperative day 1, after resumption of oral fluid intake.

## LAPAROSCOPIC PARTIAL NEPHRECTOMY

In properly selected patients, open partial nephrectomy yields oncological outcomes comparable to traditional radical nephrectomy, even over the long term. There has been an increase in the detection of small ( $\leq 4$  cm) incidentally diagnosed renal tumors, thus increasing the applicability of nephron-sparing techniques in contemporary patients with renal cancer. Finally, confidence and experience with reconstructive laparoscopic surgery has increased exponentially worldwide in recent years, with many complex abdominal reconstructive procedures now being addressed by minimally invasive techniques. As a result of the above three factors, significant interest has focused on laparoscopic partial nephrectomy, which has recently emerged as an attractive minimally invasive treatment alternative for select patients with a small renal mass.

Since 1999, we have performed more than 400 laparoscopic partial nephrectomies. Based on this experience, detailed herein is our technique for laparoscopic partial nephrectomy, including indications and contraindications, instrumentation, preoperative preparation, and tips and tricks. In general, the described technique is applicable to both the transperitoneal and retroperitoneal approaches. Whenever differences in technique exist, mention is made accordingly.

### Indications and Contraindications

Initially, laparoscopic partial nephrectomy (LPN) was reserved for a small, superficial, peripheral, exophytic renal mass, for which a wedge resection sufficed. With increasing experience, the indications of LPN have been carefully expanded to include more technically advanced cases: deeply infiltrating tumors requiring pelvicaliceal repair, larger tumors requiring heminephrectomy, hilar tumors, tumor in a solitary kidney, and LPN with hypothermia. LPN is an advanced minimally invasive procedure, wherein considerable laparoscopic experience and expertise are implicit. Contraindications for LPN currently

include a completely intrarenal and central tumor in the midpole kidney, nephron-sparing surgery (NSS) in the presence of a renal vein thrombus, and uncorrected coagulopathy. Moderate to severe azotemia is a relative contraindication to renal hilar clamping. Finally, LPN in a morbidly obese patient increases the technical complexity and should be approached with caution.

## Instrumentation

The typical laparoscopic basic set includes, among other things, the Veress needle, blunt-tip 5-mm and 10/12-mm ports, atraumatic bowel graspers, J-hook electrocautery, disposable laparoscopic scissors, Maryland grasper, Allis clamp, disposable clip applicator (10 mm, titanium) Weck hem-o-lok clips (10 mm) and applicator, right-angle clamp (10 mm), bulldog clamps, and the Carter-Thompson port-site closure device. Herein, we focus on the equipment that the author feels is particularly useful for performing LPN. The Stryker suction tip is preferred because it not only provides robust suction/irrigation, but, equally importantly, has a smooth, blunt, gently beveled tip that allows atraumatic dissection in the area of the renal hilum. The 5-mm straight Ethicon needle drivers (cat. no. E705R) are preferred because of ease of use and strong, reliable grasping. Sutured renal reconstruction is performed with a CT-1 needle 2-0 vicryl and a CTX needle 0-vicryl. The hemostatic agent Floseal (Baxter, Deerfield, IL), delivered by a reusable metal laparoscopic applicator, is used routinely. Hilar clamping is efficiently achieved with a Medtronic Satinsky vascular clamp (cat. no. CEV435-2). For retroperitoneal LPN, the working space is optimally created with the round Autosuture preperitoneal dilation balloon (OMS-PDB1000).

## Patient Preparation and Positioning

Typically, the only radiological investigation is a three-dimensional CT scan with 3-mm cuts to delineate tumor location, relation to the pelviciceal system, and define the renal hilar vessels as regards number, location, interrelationships, and any vascular anomaly. Anticoagulant medications (aspirin, plavix, coumadin) are discontinued at an appropriate time prior to surgery.

Preoperatively, two bottles of magnesium citrate are administered on the afternoon prior to the day of surgery. Following endotracheal general anesthesia, cystoscopy is performed to insert a 5 French open-ended ureteral catheter into the ipsilateral renal pelvis over a glidewire. The ureteral catheter, secured to the Foley catheter with silk ties, is connected to a 60-cc syringe filled with dilute indigo carmine dye (1 ampule indigo carmine in 500 cc saline) with intravenous extension tubing. The

syringe and intravenous tubing are maintained sterile on the operative field for intraoperative retrograde injection. For transperitoneal LPN, the patient is placed in a 45–60° lateral position, as mentioned earlier. Retroperitoneoscopic LPN is performed with the patient in the full flank position.

Selection of approach, transperitoneal vs retroperitoneal, is an important issue when performing LPN. In general, the author prefers the transperitoneal approach because it provides more working space but, even more importantly, superior suturing angles when reconstructing the partial nephrectomy defect. As such, the transperitoneal approach is employed for any anterior, anterior-lateral, or lateral tumor or a larger upper or lower pole tumor requiring polar heminephrectomy. However, for posterior tumors, the retroperitoneal approach is preferred. In deciding on the laparoscopic approach, anterior vs posterior, judgment about precise tumor location is best made on cross-sectional CT scan with 3-mm cuts. A simplistic rule of thumb in this regard is as follows: a straight line is drawn medial-to-lateral from the renal hilum to the most convex point on the lateral surface of the kidney. Any tumor located anterior to this line is approached transperitoneally, while any tumor located posterior to this line is approached retroperitoneoscopically. If the drawn line transgresses the tumor, the approach is, by default, transperitoneal.

## Intraoperative Fluid Management

Maintaining adequate intraoperative diuresis is essential. Intravenous fluid administration is tailored to the patient's baseline cardiopulmonary and renal functional status. Approximately 30–45 min before hilar clamping, we administer 12.5 g of mannitol and 10 mg of furosemide to promote diuresis. These medications are repeated just before unclamping the renal hilum, with the aim of minimizing the sequelae of renal revascularization injury, cell swelling, and free radical release and to promote diuresis.

## Port Placement (Fig. 5.10)

Pneumoperitoneum is typically obtained by the closed (Veress) needle technique. For the transperitoneal approach, the primary port (10/12 mm) is placed lateral to the rectus muscle at the level of the umbilicus. A subcostal port is placed lateral to the rectus muscle and just inferior to the costochondral margin. On the right side, this subcostal 10/12-mm port is used to facilitate passage of suture needles for the right-handed surgeon. On the left side, this subcostal port is typically a 5-mm port. A 10/12-mm port for the laparoscope is placed 3 cm inferior and medial to the subcostal port. A 5-mm port is

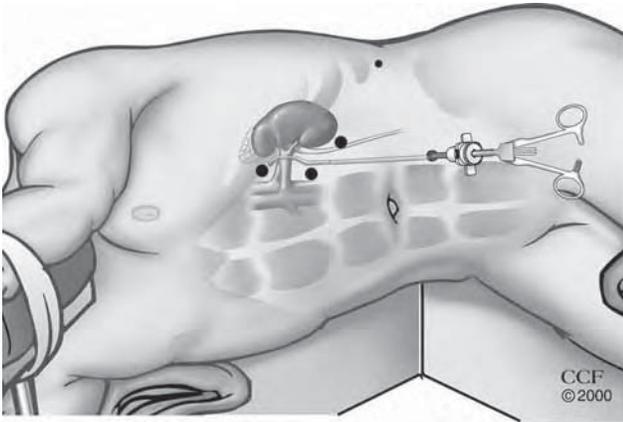


Fig. 5.10

inserted at the mid-axillary line in the vicinity of the tip of the 11th rib, and this port is employed to place lateral countertraction during renal hilar dissection and to grasp renorrhaphy stitches during renal parenchymal repair. Finally, a 10/12-mm port is placed in the suprapubic area lateral to the rectus muscle for insertion of the Satinsky vascular clamp.

Our standard retroperitoneal laparoscopic approach employs three ports. A 12–15 mm incision is made at the tip of the 12th rib, and entry is gained into the retroperitoneal space under direct vision. The retroperitoneal space is created as described previously with a balloon dilator, and a 10-mm blunt-tip balloon port is secured. A 10-mm port is placed anteriorly, approx 2–3 finger-widths cephalad to the anterior superior iliac spine. A posterior port (10/12 mm) is placed lateral to the erector spinae muscle along the undersurface of the 12th rib. For LPN, two additional retroperitoneal ports are employed. A 5-mm port is placed 3–4 cm superior to the anterior 10/12-mm port and is used for grasping the renorrhaphy sutures. Finally, a 10/12-mm port is placed in the iliac fossa just anterior to the inferior superior iliac spine and is used for inserting the laparoscopic Satinsky clamp.

### Hilar Dissection

Our essential operative strategy is as follows: renal hilar dissection first, mobilization of kidney and tumor next. On the right side, the liver is retracted anteriorly. On the left side, the spleen and pancreas are reflected medially. On either side, the ipsilateral colon is mobilized, more so on the left side than the right. The ureter and gonadal vein packet is *en bloc* dissected and lifted anteriorly off the psoas muscle. Dissection is carried towards the renal vein, which is mobilized enough to appreciate its precise location, and to visualize its anterior surface, in its entirety. We do not skeletonize the renal vein and artery individually during LPN for the following

reasons: (1) it is unnecessary for achieving adequate clamping, (2) doing so may induce renal renal artery vasospasm, (3) it risks iatrogenic vascular injury, and (4) it takes approx 30 min of important operating time, which detracts from the primary mission of the procedure. Superior to the renal hilum, the adrenal gland is dissected off the medial aspect of the upper pole kidney, which is then mobilized anteriorly off the psoas muscle. Essentially, the anterior, posterior, inferior, and superior aspects of the *en bloc* renal hilum, with some hilar fat intact, are prepared. These maneuvers allow the Satinsky vascular clamp to be deployed across the *en bloc* renal hilum with safety and confidence. Care must be taken not to miss any secondary renal arteries or veins.

### Mobilization of Kidney

Gerota's fascia is entered and the kidney defatted. We prefer removing fat from most of the renal surface for the following reasons: (1) it makes the kidney more mobile, (2) it may visualize secondary satellite tumors, (3) it allows multidirectional intraoperative ultrasound viewing, and (4) it allows more versatility for tumor resection and suturing angles. However, the peri-renal overlying the tumor and its vicinity is maintained intact, thereby allowing adequate staging for potential T3a tumors and possibly serving as a handle during tumor resection.

### Intraoperative Ultrasonography

Thorough, real-time ultrasonographic examination of the tumor is performed to facilitate planning of tumor resection. The steerable, flexible, color Doppler ultrasound probe (10-mm shaft) is employed. Information is obtained regarding tumor size, invasion depth, distance of tumor from pelvicaliceal system, and identification of any large peritumoral blood vessels. Additionally, any small satellite tumors that may have been missed on preoperative CT scanning are searched for. Under real-time ultrasonographic guidance, the proposed line of tumor excision is circumferentially scored around the tumor with the tip of a monopolar J-hook electrocautery. The oncological adequacy of this scored margin is reconfirmed ultrasonographically prior to initiating tumor resection.

### Hilar Clamping (Figs. 5.11 and 5.12)

As in open surgery, a bloodless field is an essential prerequisite for a technically precise tumor excision and collecting system and parenchymal repair. This ideal surgical field is best achieved with hilar clamping. As mentioned, the author prefers to clamp the hilum *en bloc*. The Satinsky clamp must be placed on the hilum medial to the ureter and renal pelvis, thus avoiding urothelial crush injury. One

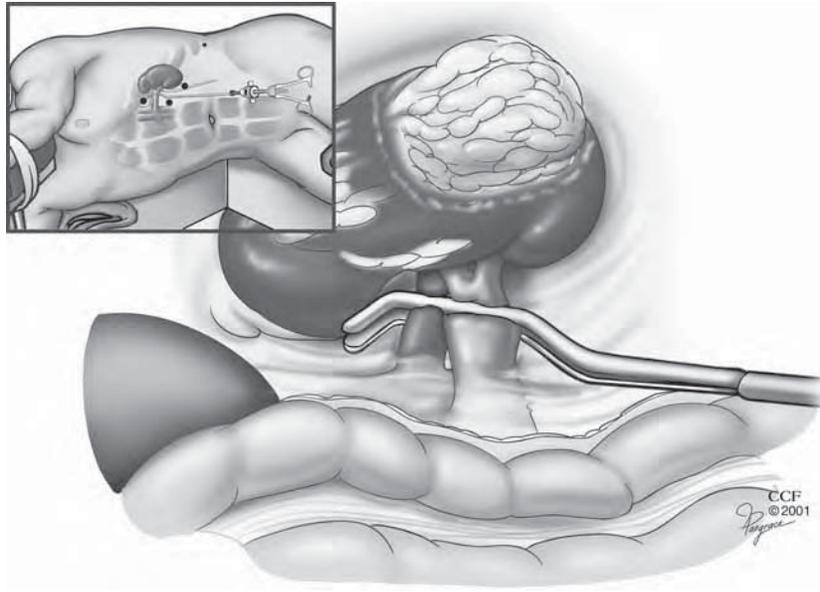


Fig. 5.11

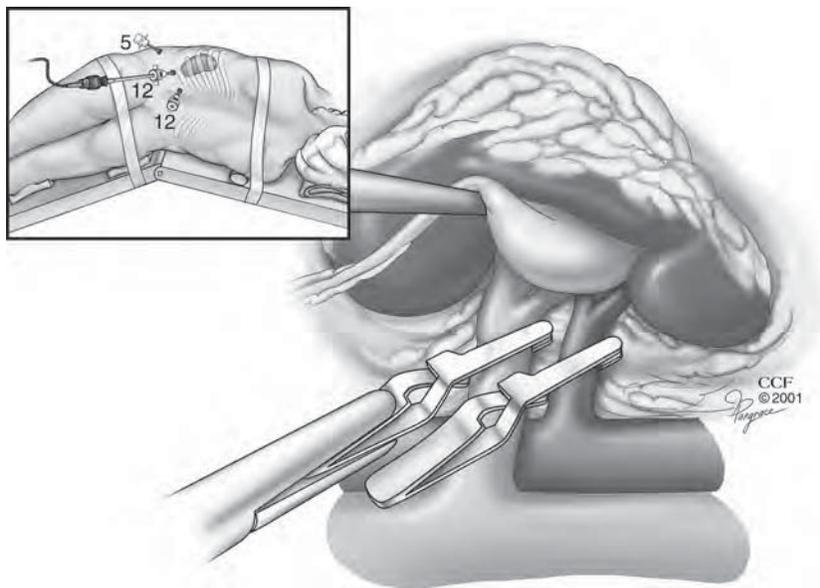


Fig. 5.12

must be certain that the entire renal hilum is enclosed within the jaws of the Satinsky. As such, the Satinsky clamp is fully opened and slowly advanced over the renal hilum in a deliberate manner, such that the jaw of the clamp facing the surgeon is anterior to the renal vein, while the posterior jaw hugs the psoas muscle. This reliably includes the renal artery and renal vein within the clamp jaws along with some hilar fat, which serves to cushion the renal vessels against clamp injury. The anesthesiologist starts a time clock to monitor the duration of warm ischemia.

In the retroperitoneal approach, the jaw of the clamp facing the surgeon lies posterior to the renal artery, while the other jaw must be anatomically anterior enough to encompass the renal vein safely. Additionally, there must be enough separation of the renal hilar structures from the peritoneum so that the clamp does not risk peritoneal entry. Alternatively, individual bulldog clamps can be placed on the renal artery and vein separately after each vascular structure has been circumferentially mobilized.

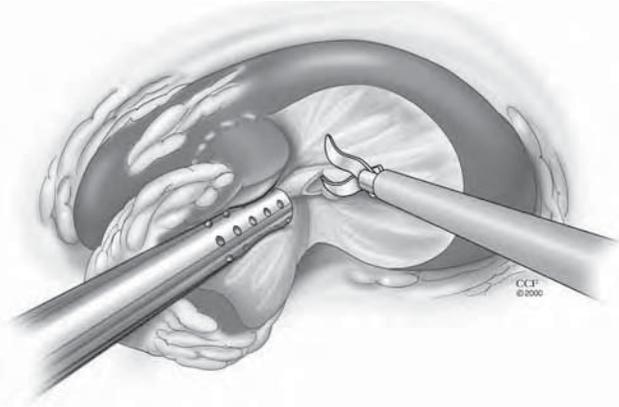


Fig. 5.13

### Tumor Resection (Fig. 5.13)

Once the hilum is clamped, tumor resection is initiated. The renal capsule is circumferentially incised with the J-hook electrocautery. Tumor resection is performed using the heavier nondisposable scissors, the jaws of which are larger than those of the disposable endoshears. Depth of tumor resection is guided by the mental map created by combining the information obtained from the preoperative CT scan, the intraoperative ultrasound examination, and laparoscopic visual cues during resection. Our aim is to obtain a margin of approx 0.5 cm around the tumor. To the uninitiated, this margin may visually appear as though an excessive amount of kidney is being excised. However, one must factor in the magnification of the laparoscope. It is most helpful for the surgeon to inspect the specimen along with the pathologist after extraction, which provides an invaluable learning experience.

### Pelvicaleical Repair and Parenchymal Hemostasis (Figs. 5.14–5.17)

The bed of the partial nephrectomy defect is oversewn with a running 2-0 vicryl on CT-1 needle. This suturing aims to achieve two specific goals: (1) precise water-tight repair of any pelvicaleical system entry, which is confirmed with retrograde injection of dilute indigo carmine through the ureteral catheter, and (2) oversewing of any large transected intrarenal blood vessels, the majority of which lie in the vicinity of the renal sinus. Individual suture repair with figure-of-eight stitches can be performed of any additional blood vessels, as necessary.

Parenchymal renorrhaphy is performed with 1-vicryl on a CTX needle. The suture is cut to port length, and a hemostatic Weck clip is preplaced 4–5 cm from the tail end of the suture to serve as a pledget. Renal parenchymal stitches are placed over a preprepared oxidized cellulose bolster (Johnson & Johnson, New Brunswick, NJ). These

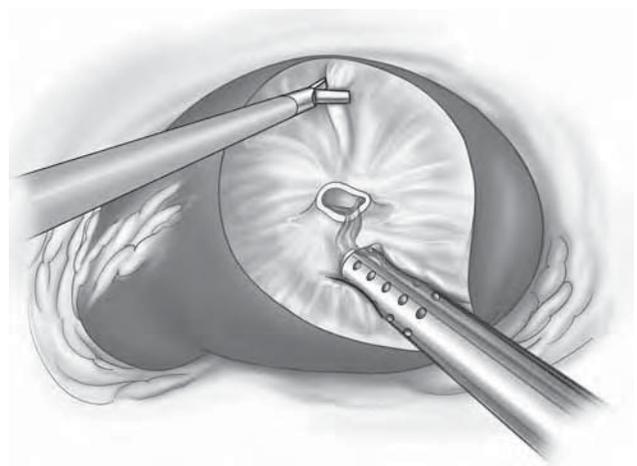


Fig. 5.14

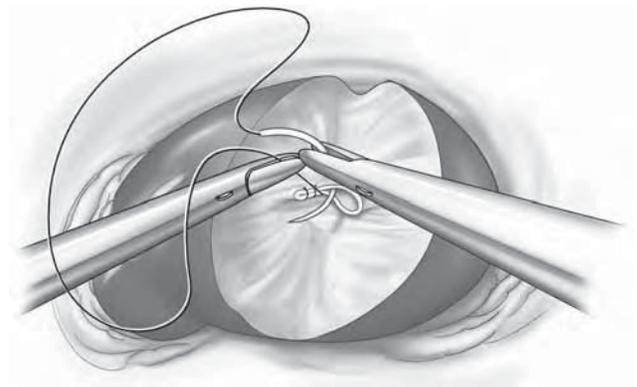


Fig. 5.15

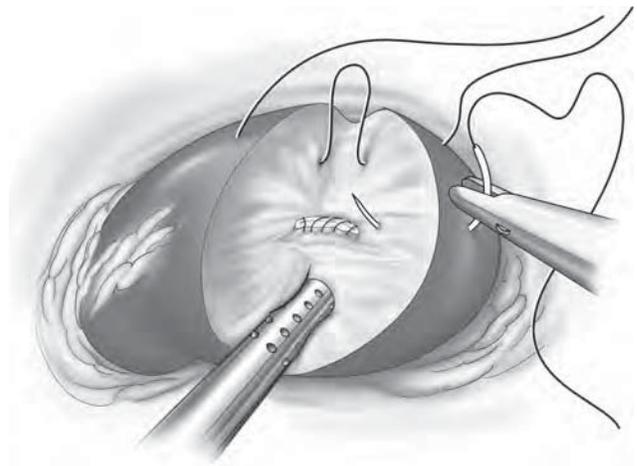


Fig. 5.16

parenchymal stitches are placed meticulously, wherein the desired angle and depth of needle passage is preplanned to prevent multiple passages, thus minimizing possible puncture injury to the intrarenal blood vessels. This pre-fashioned Surgicel bolster is positioned underneath the

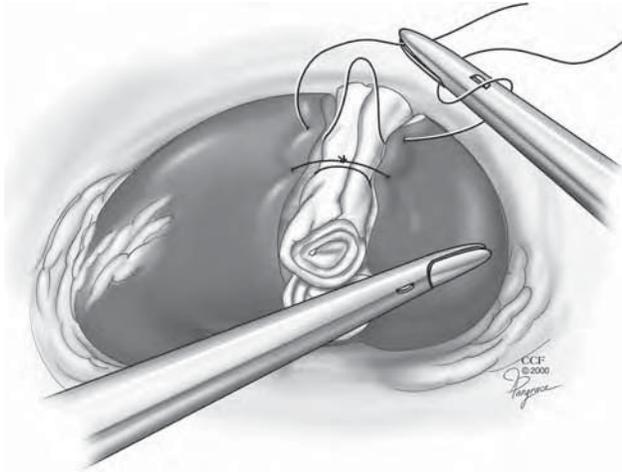


Fig. 5.17

suture loop. Using the 5-mm metal applicator, the gelatin matrix thrombin sealant Floseal (Baxter, Deerfield, IL) is layered directly onto the partial nephrectomy bed underneath the Surgicel bolster. The suture is tightened, compressing the bolster firmly onto the partial nephrectomy bed. Another Weck clip is placed on the exiting suture flush with the parenchyma, thus maintaining consistent pressure. The two suture tails are tied to one another with a surgeon's knot. With the suture cinched down, an assistant grasps the knot with the Maryland grasper to hold the suture secure at this point of maximal tension. The surgeon places two additional knots, securing the stitch. We believe that mere placement of a clip as a pledget on either end of the suture does not provide enough security of parenchymal compression, leaving the potential for bleeding from the edges of the partial nephrectomy defect. As such, tying the suture tails across the bolster over the partial nephrectomy is important to coapt the edges of the parenchymal defect. Typically, three to five parenchymal renorrhaphy sutures are required to close the entire defect.

### Hilar Unclamping

A repeat 12.5-g dose of mannitol and 10–20 mg of furosemide are administered intravenously 1–2 min before unclamping the renal hilum. The Satinsky clamp jaws are opened, but not yet removed, in order to assess the adequacy of hemostasis from the partial nephrectomy bed. Once satisfied, the clamp is slowly and carefully removed under direct vision. The entrapped specimen is extracted intact by slightly extending one of the port-site incisions. A Jackson–Pratt drain is placed during transperitoneal LPN, and a Penrose drain is placed following a retroperitoneoscopic LPN. Fascial closure of 10/12-mm port sites is achieved with the Carter–Thompson device. The partial

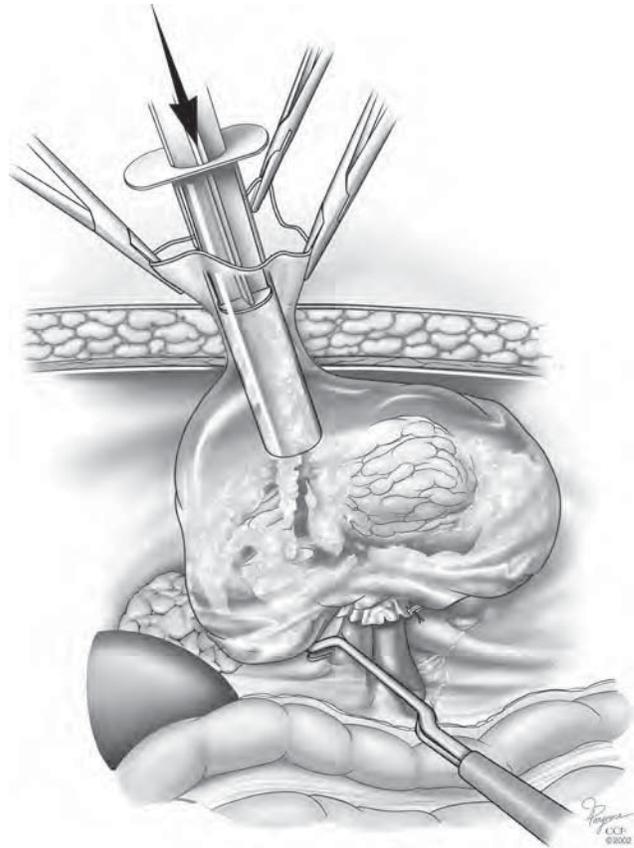


Fig. 5.18

nephrectomy bed is reinspected laparoscopically after 5–10 min of desufflation to confirm complete hemostasis.

### Renal Hypothermia (Fig. 5.18)

We recently developed the technique of laparoscopic ice-slush hypothermia during LPN. Finely crushed ice slurry is preloaded into 30-cc syringes, whose nozzle-ends have been cut off. The mobilized kidney is entrapped in an Endocatch-II bag, whose drawstring is cinched down around the intact renal hilum, thus completely entrapping the kidney. The renal hilum is clamped with a Satinsky clamp. The bottom end of the bag is retrieved outside the abdomen through the inferior para-rectal port site. The bottom end of the bag is opened, and the preloaded syringes are used to rapidly fill the intra-abdominal bag with ice slurry. Typically, 4–7 min are required to fill the bag with 600–900 cc of ice slurry, thus surrounding the entire kidney under laparoscopic visualization. After allowing 10 min for achievement of core renal cooling, the bag is incised, the ice crystals removed from the vicinity of the tumor, and partial nephrectomy completed. In 12 patients, needle thermocouples were used to document nadir renal parenchymal temperatures of 5–19°C, attesting to the efficacy of the achieved hypothermia. Recently,

two additional methods of achieving renal hypothermia by either retrograde ureteric perfusion or intra-arterial perfusion have been reported.

### Postoperative Care

The patient is advised strict bed rest for 24 h, followed by gradual mobilization. The ureteral and Foley catheters are removed on the morning of postoperative day 2 as the patient begins ambulation. The peri-renal drain is maintained for at least 3–5 d and removed when the drainage is less than 50 cc per day for 3 consecutive days. Following discharge from the hospital, the patient is advised restricted activity for 2 wk. Any physical activity with the potential to jar the renal remnant is inadvisable in the early postoperative period. A MAG-3 radionuclide scan is performed at 1 mo to evaluate renal function and assess pelvicaliceal system integrity. In patients with pathologically confirmed renal cancer, a follow-up CT scan and chest X-ray are obtained at 6 mo. Subsequent oncological surveillance is as per the individual pathological tumor stage.

### Complications

In our analysis of complications in the initial 200 patients undergoing LPN for renal tumor, we documented a complication rate of 33% (urological 18%, other 15%). This included hemorrhagic complications in 9.5%, urine leak in 4.5%, and open conversion in 1%, with no perioperative mortality. More recently, we have incorporated routine use of the gelatin matrix thrombin sealant Floseal during LPN. As such, in our most recent 100 patients, the rate of hemorrhagic complications has decreased to less than 3% and urine leak to less than 1.5%, mirroring current open surgical outcomes.

## LAPAROSCOPIC RENAL CRYOABLATION

### Indications

With increasing experience in laparoscopic techniques and availability of an increased number of options for NSS, our indications for renal cryoablation have become more selective. As such, at this writing, we offer renal cryoablation to only a select subgroup of patients who have a small (less than 3 cm) tumor at a nonhilar location. Such patients typically are older, may have mild to moderate baseline azotemia, and prefer NSS over watchful waiting. The patient is clearly informed about the current developmental nature of cryoablation and the consequent need for vigorous postoperative surveillance (*see* Postoperative Follow-Up).

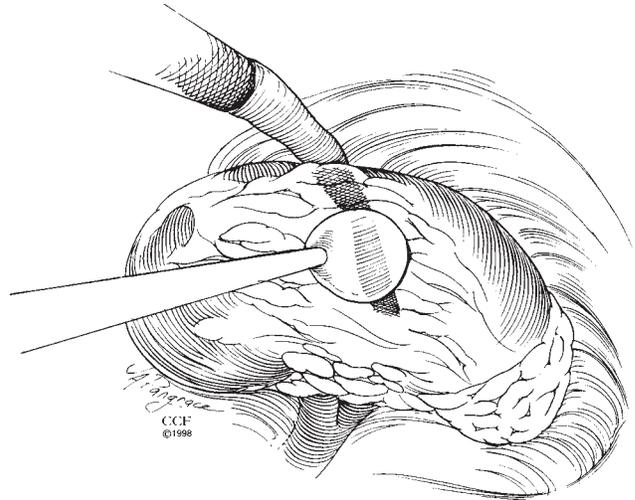


Fig. 5.19

### Patient Positioning and Port Placement

Either the transperitoneal or the retroperitoneal approach is employed depending on tumor location, considerations similar to those listed in the preceding section on laparoscopic partial nephrectomy. Port placement is also similar (port for vascular clamp is not necessary).

### Mobilization of Kidney (Fig. 5.19)

No attempt is made to dissect the renal hilar vessels. The kidney is completely mobilized within Gerota's fascia, exposing the entire renal surface, including the tumor. The peri-renal fat overlying the tumor is removed for histopathological examination. Such mobilization of the kidney has two advantages: complete ultrasound examination of entire kidney surface is feasible, and the tumor can be properly aligned for cryoprobe puncture.

### Ultrasonographic Examination

An endoscopic, steerable color Doppler ultrasound probe is inserted through an appropriate port and placed in direct contact with the kidney surface. Detailed ultrasound examination of the entire kidney is performed to evaluate the following: tumor size, margins, vascularity, distance of the deep tumor edge from the collecting system, and any satellite tumors. During real-time monitoring of the cryoablation process, the ultrasound probe is placed in contact with the kidney surface that is directly opposite to the tumor. As such, adequate renal mobilization is necessary to create space for ultrasound probe placement.

### Needle Biopsy of Tumor

A 15-gage, 15-cm Tru-Cut needle with echogenic tip (ASEP Biopsy System, Order No. 500-128, Microvasive, Boston Scientific, Watertown, MA) is employed to perform

needle biopsy of the tumor prior to cryotherapy. This biopsy needle is introduced through a 2-mm port inserted specifically for this purpose. To optimize accuracy, two to three needle biopsies are taken under direct laparoscopic visualization and real-time ultrasound monitoring. The tissue is sent for permanent histopathological examination.

### Cryoprobe Puncture (Fig. 5.20)

Typically, we employ a 4.8-mm cryoprobe of an argon-gas-based system (Endocare). It is critically important to ensure that the cryoprobe enters the precise center of the tumor at right angles to the tumor surface. Also, the tip of the cryoprobe should be advanced up to, or just beyond, the inner margin of the tumor. For example, for a 2-cm tumor, the cryoprobe should be inserted approx 2.2 cm into the renal parenchyma under ultrasound and laparoscopic guidance. It is helpful to premark this length on the shaft of the cryoprobe with a marking pen. For tumors approaching 3 cm in size, one may consider using two cryoprobes instead of one.

### Cryoablation (Fig. 5.21)

A double freeze–thaw cycle is performed under real-time endoscopic ultrasound monitoring and laparoscopic visualization. A rapid initial freeze is performed (tip temperature  $-140^{\circ}\text{C}$ ) until the advancing hyperchoic, semilunar edge of the ice ball is noted to circumferentially extend approx 1 cm beyond the tumor margins on ultrasound. Obliteration of vascularity and blood flow within the anechoic ice ball is confirmed by color Doppler. Laparoscopic visualization confirms that the entire exophytic surface of the tumor is covered with the ice ball, including approx 1 cm of healthy margin. *Note:* It is vital that the extra-renal surface of the ice ball in its entirety is in clear laparoscopic visualization at all times. Even momentary contact of the ice ball or the active cryoprobe with the adjacent peritoneum, ureter, bowel, or other abdominal viscerae is unacceptable and likely to result in serious sequelae owing to thermal freeze injury. Upon completion of the initial freeze cycle (endpoint: ice ball completely surrounding the tumor), a passive thaw is performed. This slow complete thaw is terminated when the laparoscopically visible ice ball begins to melt. With the cryoprobe carefully maintained in position, a second rapid freeze is performed. Monitoring of the second freeze is completely by laparoscopic visualization. Ultrasonography is not helpful with the second freeze, since the ice ball created by the initial freeze renders the ablated area anechoic, and therefore ultrasonographically invisible. On completion of the second freeze, an active thaw is

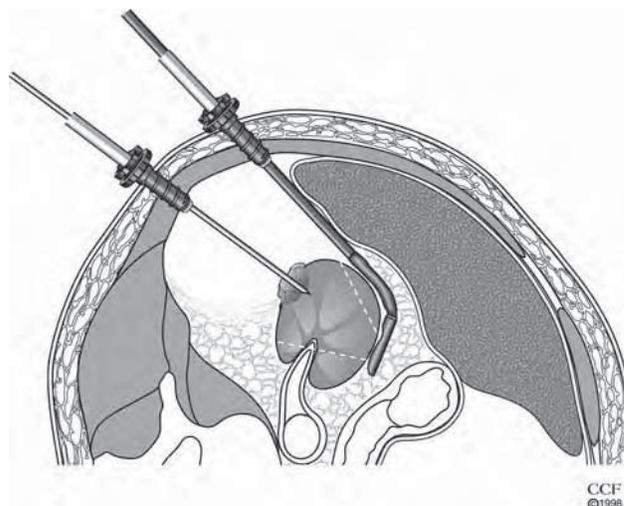


Fig. 5.20

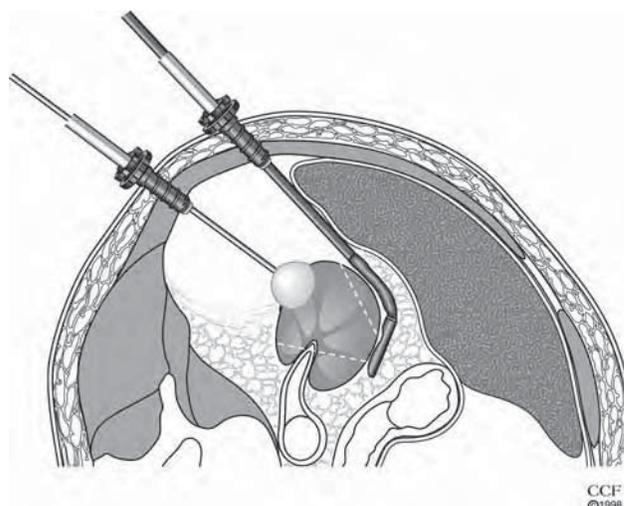


Fig. 5.21

performed. Melting of the cryolesion releases the probe, which is removed gently without any torquing. Premature removal may create parenchymal fracture lines, which may result in hemorrhage. Upon removal of the cryoprobe, Floseal is injected into the cryopuncture site and over the entire cryoablated tumor. Hemostatic pressure is maintained with a piece of Surgicel. Argon beam coagulation is employed as necessary for hemostasis. Reinspection to confirm hemostasis is performed after 10–15 min of decreased pneumoperitoneum. Typically, no peri-renal drain is placed.

### Postoperative Follow-Up

Given the developmental nature of cryoablation, follow-up is rigorous to ensure oncological adequacy. Our protocol comprises of biochemical, radiological, and

histopathological evaluation. The aim of this follow-up is to document continuous shrinkage of the cryoablated tumor without any evidence of tumor growth, lack of shrinkage, or suspicious nodular enhancement. We obtain a magnetic resonance imaging (MRI) scan on postoperative day 1 to obtain a baseline image. Follow-up MRI scans are performed at 1, 3, and 6 mo and every

6 mo thereafter for 2 yr followed by yearly MRI scanning. Chest x-ray is performed at yearly intervals. At 6 mo postoperatively, a CT-directed percutaneous needle biopsy of the cryoablated tumor site is performed for histopathological evaluation. Complete blood count and metabolic panel, including serum creatinine, are performed.