Laparoscopic Partial Nephrectomy

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Laparoscopic partial nephrectomy (LPN) was introduced in 1993 by Winfield and his colleagues. While it has engendered much controversy, the procedure is rapidly evolving towards a standard of care management strategy for small renal cortical neoplasms.[1] Many initial reports on LPN described application of novel energy technologies and surgical pharmaceuticals to simplify the laparoscopic technique and to eliminate the need for reconstructive components of the procedure. However, with time and experience, most surgeons experienced with LPN currently reproduce the traditional open technique with suture reconstruction of the collecting system and the renal parenchymal defect in a bloodless field after renal hilar control. While the procedure remains technically challenging, LPN does offer patients an oncologically effective treatment while maintaining the advantages of a minimally invasive approach.

Patient Selection:

Patient selection is the key factor in optimizing patient outcome and minimizing patient morbidity. Patient selection should depend on the surgeon's level of comfort and experience with laparoscopy and laparoscopic reconstructive technique. Small and very exophytic lesions may be managed without vascular control and do not involve violation of the renal collecting system. In these cases, hemostasis can commonly be achieved with energy sources like the argon beam coagulator or Floating Ball wet monopolar energy (Tissue Link Medical, Inc, Dover, NH). However, most renal cortical neoplasms do demand vascular control for safe extirpation with a negative margin.

Advances in available ablative and reconstructive laparoscopic technology have expanded our ability to perform minimally invasive partial nephrectomy. Currently, and with experience, the majority of patients who are candidates for partial nephrectomy can have their procedures performed laparoscopically. Generally, patients with renal masses smaller than four centimeters are considered candidates for laparoscopic partial nephrectomy. However, for imperative indications (solitary or functionally solitary kidney) larger renal masses may be managed with a laparoscopic partial nephrectomy.

Larger or more centrally located masses require dissection of the renal hilum and vascular control with either laparoscopic Satinsky clamps or laparoscopic vessel clips "bulldog clamps" (Aesculap, Center Valley, PA). These cases are more challenging and frequently require intracorporeal suturing to close collecting system defects and/or the renal parenchyma.

When considering laparoscopic partial nephrectomy the surgeon should consider four factors that will impact on the technical level of difficulty of the procedure: 1) The amount of renal parenchyma that will require transection to excise the renal mass with an adequate margin of normal tissue, 2) involvement of the renal collecting system that may need closure if violated, 3) the amount of perinephric fat in the specimen which can be determined on pre-operative CAT or MRI scans, 4) proximity of the mass to vital structures like the renal vasculature or renal pelvis/ureter.

Patient Positioning and Laparoscopic Access:

After general anesthesia is obtained, the patient is placed in the lateral decubitus position, and pressure points at the shoulder, hip, knees and ankles are carefully padded. An axillary role is placed under the dependent shoulder to minimize the possibility of injury to the brachial plexus, and the patient is positioned so that the anterior superior iliac spine is at the point of the table break. The table is then partially flexed and the space between the iliac crest and the costal margin is extended to provide maximal working space.

Patient positioning for transperitoneal laparoscopic procedures differs from open flank cases in that the patient's ventral surface must lie near the edge of the operative table. This allows the longer laparoscopic instruments to be moved down during lateral portions of the dissection. If the patient is positioned centrally on the table, then the surgeon's instruments will be limited by the operative table itself. During retroperitoneal access this is not a problem and the patient can be positioned in the middle of the operative table.

The patient is carefully anchored to the bed with straps placed over the chest and hips. The anchoring strap placed at the hip can be placed snugly, however, the chest strap must be left sufficiently loose to prevent constriction of the chest

wall. Checking inspiratory pressures prior to starting the procedure can be very useful in this regard.

The patient's abdomen and flank are then prepped and draped in a sterile fashion. Laparoscopic access technique is dependent on the surgeon's preference and either Veress needle, Hasson, or direct vision access may be employed. Initial trocar placement is dependent on the approach (transperitoneal vs. retroperitoneal) and on a history of previous surgery in the quadrant where the trocar will be placed. We prefer direct vision access in the ipsilateral lower quadrant inferior and medial to the anterior superior iliac spine for the transperitoneal approach, and Hasson access via a 1.5 cm incision at the tip of the twelfth rib for the retroperitoneal approach. Trocar templates for laparoscopic transperitoneal and retroperitoneal access are presented in figures 1 and 2 respectively.

Figure 1 – Trocar placement for right and left transperitoneal laparoscopic partial nephrectomy. (Blue = 12 mm port sites, Red = 5 mm port sites).

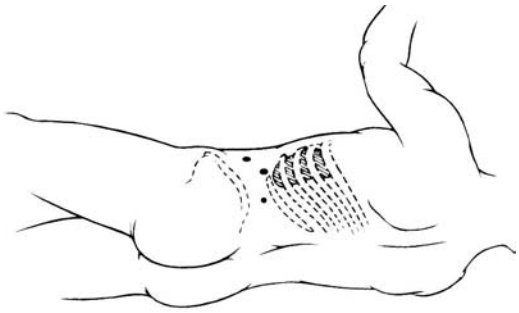

Figure 2 – Trocar placement for left retroperitoneoscopic partial nephrectomy.

The decision to go transperitoneal or retroperitoneal is usually based on the location of the tumor (Figure 3). If the tumor is located anteriorly, it is usually best approached via the transperitoneal approach. Posterior tumors are best approached using retroperitoneal access techniques. Other factors like prior surgery and the surgeon's experience are certainly important considerations. A transperitoneal approach for reconstruction is considered by most experienced surgeons to be preferable as there is superior working space. However, forcing a transperitoneal approach on a very posterior tumor will result in poor working angles

Figure 3 – CT scan demonstrating possible locations of small renal masses. The type of laparoscopic approach is determined by mass location. Anterior masses (red) are generally approached via the transperitoneal route while posterior masses (yellow) are approached retroperitoneally. Lateral masses (white) may be approached by either access method.

for extirpation and reconstruction and can complicate the procedure. As such, the location of the tumor should be considered in patient selection for LPN.

Laparoscopic Transperitoneal Partial Nephrectomy:

After initial trocar placement, and achieving pneumoperitoneum of 15 mm Hg, two additional 12 mm trocars are deployed: one cephalad to the umbilicus (or lateral to the rectus muscle at the level of the umbilicus in more obese patients) to be used for the laparoscope, and another trocar at the costal margin in the midclavicular line. An optional 5 mm trocar is often placed in the posterior axillary line for a retractor. For right-sided partial nephrectomy, an additional 5 mm trocar is often deployed in a subxiphoid position to assist in liver retraction.

The colon is then mobilized off of the anterior surface of Gerota's fascia by incising the peritoneal reflection just medial to the white line of Toldt. The lateral and posterior retroperitoneal attachments of Gerota's fascia are maintained intact to prevent medial mobilization of the kidney within Gerota's fascia. We have found the Harmonic ACE™ (Ethicon Endosurgery, Cincinnati, OH) to be very useful for this dissection as it provides excellent hemostasis without extensive lateral energy spread. In addition, we use Sovereign® Bipolar Macro Graspers (Aesculap, Center Valley, PA - see Figure 4) in the surgeon's non-dominant hand.

Figure 4 – Sovereign® Bipolar Macro Graspers (Aesculap, Center Valley, PA)

The advantage of simultaneously applying two energy instruments is that small bleeding sites that may be difficult to control with the Harmonic ACE are easily coagulated with the precision of bipolar cautery. In addition, the bipolar grasper jaws are remarkably atraumatic with excellent grasping capabilities that make it very useful for gross and fine tissue manipulation. By utilizing these two instruments for routine dissection, the surgeon can work very expeditiously and safely.

The only disadvantage of applying two energy instruments has been the need for two pedals. At first, this is challenging as the surgeon will be tempted to take his eyes off of the monitor to find the foot pedals. To eliminate this problem, we have attached the Harmonic Scalpel and bipolar pedals together in an intuitive manner (Figure 5). By taping the pedals together in this configuration the surgeon will always know where the pedals are without taking his/her eyes off of the monitor. This technique also prevents inadvertent activation of the "wrong" instrument.

Figure 5 – Foot pedal configuration for simultaneous use of the bipolar electrocautery and the harmonic scalpel (Bipolar pedal is taped to a ridge on the harmonic scalpel pedal so the pedals remain fixed in place).

The colon is mobilized off the retroperitoneum from the level of the iliac vessels to the hepatic flexure for right-sided partial nephrectomy or to the splenic flexure for left-sided partial nephrectomy. On the right side once the colon has been reflected medially, the duodenum will be exposed and must also be mobilized medially to expose the renal hilum. On the left side, the tail of the pancreas may require a bit of dissection to expose the renal vasculature.

Small very exophytic tumors that will require only a small amount of parenchymal transection for complete excision can be managed without hilar control. Typically, these tumors are visible as a small bulge through Gerota's fascia. Close inspection of pre-operative imaging will frequently allow the surgeon to quickly determine the location of the tumor.

Patients with a large amount of perinephric fat are frequently more challenging, as the location of the tumor may be more difficult to discern, and subsequent dissection is also more difficult. If the tumor is not evident by visual inspection, real-time ultrasound with a deflectable laparoscopic ultrasound probe (Aloka, Wallingburg, CT) is very effective in tumor localization. The ultrasound probe is initially not intuitive to use. However, with experience and practice, the laparoscopic ultrasound becomes a very valuable tool.

Currently, we use the laparoscopic ultrasound to locate the target lesion, characterize the lesions depth of penetration to help assure a negative margin, and to confirm that hilar control is complete after clamping using the duplex setting. The laparoscopic ultrasound is also used to evaluate the rest of the kidney as the high frequency probe is very sensitive and can identify small lesions that may be missed on CT or MRI evaluations.

Once the tumor has been located, Gerota's fascia and the perinephric fat around the tumor are incised down to the renal capsule. Generally, these tissues are left on the tumor, but they may be sent as a separate specimen if they do not remain adherent to the renal mass during the dissection. If Gerota's fascia and the perinephric fat are separated from the specimen, they are placed in an Endocatch™ entrapment sac (US Surgical, Norwalk, CT), removed through one of the trocar sites, and sent for final pathology.

Tumor Excision Without Vascular Control

Renal parenchymal transection is initiated by scoring the renal capsule with the Harmonic ACE. Scoring the capsule at the selected site of renal transection is important as it can help delineate the transection line once bleeding has started. We prefer to remove enough perinephric fat to establish a 1.5 cm margin around the renal lesion. This helps assure clear transection margins as the excision proceeds. For these small exophytic tumors, it is feasible to perform pre-coagulation of the surrounding parenchyma to prevent bleeding. The Floating Ball (Tissue Link Medical, Inc., Dover, NH) device uses a saline drip to cool the tissue as it is coagulated. This prevents local charring which increases local tissue

impedance and prevents deeper hemostasis. Thus, this device allows for deeper tissue coagulation.

The floating ball is slowly run over the transection line using a coagulation current of 80 watts. The drip rate is kept at one drop per second. The best coagulation effect is achieved when small bubbles are noted. The energy and drip rate may be adjusted to achieve these small bubbles. The process of pre-coagulation is a bit time consuming as the Floating Ball produces smoke, which needs to be regularly evacuated.

Once the tissue has been pre-coagulated, the renal parenchyma can usually be transected with only minimal bleeding. Small bleeding sites can be controlled by application of the Floating Ball device. The working element of the device is applied in a circular motion around bleeding parenchymal vessels making progressively smaller concentric circles around the bleeding site. Unclamped partial nephrectomy is currently infrequently performed, and the procedure should be reserved only for the most exophytic small lesions.

Tumor Excision with Vascular Control

With experience, it is clear that the vast majority of small renal cortical neoplasms are best treated with vascular control prior to transection in the majority of renal masses. Obtaining vascular control prior to renal parenchymal transection allows for better visualization of the transected tissue and better assessment of the renal bed to assure a negative margin. The availability of simple and effective atraumatic vascular clamps has made laparoscopic vascular control a very reasonable option.

The renal vessels are dissected free from surrounding tissues and hilar fat. For most renal cortical neoplasms, two bulldog clamps (Aesculap, Center Valley, PA - see Figure 6) are currently used to control just the renal artery. For most renal arteries, two bulldog clamps are used to assure complete compression of the renal artery. Recently, Box and colleagues have demonstrated that the Aesculap bulldogs manifest the highest compression strength among the currently available bulldog clamps.[2] When bulldog renal artery clamping is employed, a careful dissection of the artery is performed to maximize compression on the vessel. For very central or hilar tumors we currently prefer a laparoscopic Satinsky clamp (Aesculap, Center Valley, PA) to assure optimal hemostasis (Figure 7). In these cases we typically do not make any attempt to separate the artery and vein. Indeed, we attempt to dissect out the renal artery and vein with some of the surrounding adventitial tissue. In theory, this allows a cushion of tissue to exist around vessels for application of the laparoscopic Satinsky vascular clamp. At times, dissection of the renal vessels as a single packet is not possible as the vessels are separated by some distance. The CAT scan or MRI is usually helpful in determining the location of the renal vasculature. Placement of the optional fourth trocar (Figure 1) and retraction of the ureter or kidney as discussed earlier may facilitate the hilar dissection.

Figure 6 – Laparoscopic Vascular Bulldog Clamps (Aesculap, Center Valley, PA)

Figure 7 – Laparoscopic Satinsky Clamp , short & long jaw (Aesculap, Center Valley, PA)

When deploying the laparoscopic Satinsky clamp, there are two mechanisms for deploying the instrument. First, the instrument can be deployed through a flexible trocar (Aesculap, Center Valley, PA - see Figure 8). Alternatively, we have found it very easy to deploy the laparoscopic Satinsky

Figure 8 – Flexible Trocar (Aesculap, Center Valley, PA)

clamp by making a 3 mm incision in the skin and gently pushing the instrument into the abdominal cavity under direct laparoscopic vision. Often we prefer to deploy the Satinsky clamp through the umbilicus where the small incision remains imperceptible after healing.

Once the hilum has been dissected, and the renal lesion has been identified, Gerota's fascia and the perinephric fat overlying the target lesion are incised as previously described. The entire lesion must be exposed along with a circumferential area of normal parenchyma measuring at least 1.5 cm, and the renal capsule is scored along the anticipated line of transection. Pre-operative imaging and the laparoscopic ultrasound probe may help judge the depth of parenchymal penetration.

Fifteen minutes prior to vascular occlusion, 12.5 – 25 mg of IV mannitol is given to the patient to promote diuresis. Laparoscopic bulldog clamps (Figure 6) and Satinsky clamps (Figure 7) are both effective and easy to use for obtaining vascular control of the renal hilum. We have identified several "tricks" that facilitate the deployment and the removal of the laparoscopic bulldog clamps. We use the applicator device to both place and remove the clamps. The surgeon should familiarize him/herself with the device prior to its application. After renal clamping, a quick evaluation of the kidney with the laparoscopic ultrasound using the duplex setting confirms that all blood flow the organ has been transiently interrupted. If blood flow is detected on duplex evaluation, the clamps are removed and a search for additional arteries is initiated.

The large curved bulldog clamp is usually best suited for renal hilar clamping. For smaller renal arteries, this clamp alone is used. If the renal artery is more robust, two laparoscopic bulldog clamps are typically employed. We have found the bulldog clamps to be very effective for vascular control. The bulldog clip applicators are 12.5 mm in diameter, and can be deployed through standard 12 mm trocars. To facilitate bulldog clamp removal, a Maryland grasper is used to anchor the bulldog clamp, and the bulldog remover is deployed through the same trocar which was used to deploy the bulldog. Using the same trocar during bulldog extraction, and anchoring the bulldog with the contralateral hand, facilitate and expedite engaging the bulldog remover with the clamp. Using this technique, we have not had any problems placing or removing the clamps. While it remains controversial, most experts believe that renal ischemic times should be kept under 30 minutes unless some type of renal parenchymal hypothermia is employed.

Once vascular control has been obtained and confirmed, cold shears are used to excise the target lesion and a margin of normal tissue. The surgeon can take advantage of the angle of the scissors to increase or decrease the depth of the incision. For larger lesions, we have found the 10 mm large Metzenbaum scissors (Aesculap, Center Valley, PA - see Figure 9) effective to expedite parenchymal transaction. The larger scissors also provide a smoother surface of the defect that may facilitate identification and suture control of vessels and the renal collecting system.

Figure 9 – 10 mm large Metzenbaum scissors (Aesculap, Center Valley, PA)

The area of renal transaction is closely inspected. Any obvious vessels are grasped with the Sovereign® Bipolar Macro Graspers (Aesculap, Center Valley, PA) and coagulated. Larger vessels are sutured with 4-0 Vicryl using Durogrip® Needle Holders (Aesculap, Center Valley, PA - see Figure 10. We then treat the cortical surface of the renal defect with the Floating Ball device as previously described. Any violation of the collecting system is then closed with absorbable 4-0 Vicryl sutures using intracorporeal suturing techniques. If significant violation of the collecting system is anticipated (eg. with hilar or central tumors), a ureteral catheter is placed prior to the laparoscopic component of the procedure to allow retrograde instillation of sterile saline for careful identification of collecting system defects. With laparoscopic cases, instillation of Indigo Carmine or Methylene Blue through the retrograde catheter should <u>not</u> be used as the dark fluid diminishes the light and diminishes the view of the surgical field. Floseal (Baxter, Deerfield, Ill) is then applied to the surface of the lesion for additional hemostasis.

Figure 10 – Durogrip needle holder (Aesculap, Center Valley, PA)

The vascular bulldog clamp is then removed and the renal defect is examined for hemostasis. The specimen is then removed, usually through the lower quadrant port-site and

sent for pathologic frozen section to check the margins of resection. The extraction incision should be relatively generous to prevent fracturing of the specimen which can yield a false positive margin. Once negative margins have been confirmed histopathologically, the intra-abdominal pressure is reduced to 5 mm Hg and the surgical area is examined for hemostasis. Additional hemostasis is obtained with the floating ball when needed.

Once hemostasis is confirmed, a suction drain is placed near the renal defect when collecting system violation has occurred. Drain placement is dependent on surgeon experience and preference, however we strongly advise placement of drains for patients with known defects in the collecting system. All trocars are then removed under direct vision. The fascia of the trocar sites is closed with a fascia port-closure device if needed, and the skin is closed with a topical skin adhesive or with subcuticular sutures.

Laparoscopic Retroperitoneal Partial Nephrectomy:

Retroperitoneal access is typically obtained via a 1.5 cm incision at the tip of the twelfth rib. The surgeon's index finger is used to bluntly dissect the retroperitoneal space using the psoas muscle as a landmark. The inferior pole of the kidney is often palpable during this portion of the dissection. A dilating balloon (US Surgical, Norwalk, CT) is used to create a working space within the retroperitoneal cavity. Upon inspection with pneumoretroperitoneum of 15 mm Hg, the psoas muscle should be easily identified. The pulsations of the renal artery are often seen after initial balloon dilatation. Two additional 12 mm trocars are placed; one at the costovertebral angle and another subcostally after the peritoneum has been mobilized medially (Figure 2). The ureter is identified and the renal hilar vessels are dissected and exposed for vascular clamping. After hilar dissection, the steerable laparoscopic ultrasound probe will help to localize the renal lesion. Laparoscopic partial nephrectomy then proceeds in a manner similar to the transperitoneal approach.

Postoperative Care

A complete blood count is usually obtained in the post-anesthesia care unit and then on the morning of the first post-operative day. Patients receive Ketorolac for pain, which is supplemented with opiate analgesics as needed. A clear liquid diet is given on the evening of surgery, and the diet is advanced to regular as tolerated. If a drain has been deployed, the drain fluid is routinely sent for creatinine levels. If the levels are low, the drain can be removed even with moderate drainage. If the drain fluid creatinine is elevated, the patient is managed for urinary leak as per standard protocols. Patients are discharged when hemodynamically stable, comfortable on oral analgesics, tolerating a regular diet, and ambulating. This is typically is on the first or second post-operative day.

Post-operative imaging and subsequent follow-up are as per surgeon preference and should be consistent with open partial nephrectomy.

Summary:

With currently available technology, laparoscopic partial nephrectomy has become a clinical reality. Advances in energy technologies, instrumentation, and laparoscopic surgical skills have made a significant impact on the current standard of care. Laparoscopic partial nephrectomy remains technically challenging and should be approached with caution. Careful case selection early in the surgeon's experience will help avoid complications.

References:

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