LAPAROSCOPIC NEPHRON-SPARING SURGERY IN THE PRESENCE OF RENAL ARTERY DISEASE
ANDREW P. STEINBERG, SIDNEY C. ABREU, MIHIR M. DESAI, ANUP P. RAMANI, JIHAD H. KAOUK, AND INDERBIR S. GILL

ABSTRACT

Introduction. To describe the technical considerations of laparoscopic nephron-sparing surgery in 3 complicated cases involving kidneys with renal arterial disease.

Technical Considerations. Three candidates for nephron-sparing surgery each had a renal mass, measuring 5.0, 3.5, and 2.5 cm, respectively. The renal arterial pathologic features in the tumor-bearing kidney included renal artery stenosis treated by percutaneous angioplasty and stenting in 1 patient and upper pole intrarenal aneurysm in 1 patient; the final patient had previously undergone aortorenal bypass grafting. The preoperative serum creatinine in the 3 patients was 2.1, 1.0, and 2.5 mg/dL, respectively. Two patients had a solitary functioning kidney. Laparoscopic partial nephrectomy with hilar clamping was performed in 2 patients and laparoscopic renal cryoablation in 1 patient. Laparoscopic Doppler ultrasonography was used in each case. The total operative time for the 3 patients was 2.3, 4.0, and 2.8 hours, respectively. The warm ischemia time in the first 2 cases was 28 and 39 minutes, respectively. The blood loss was 50, 400, and 100 mL. Pathologic examination revealed renal cell carcinoma in 2 cases and a calcified aneurysm in 1 case. The hospital stay was 7, 4, and 2 days. The postoperative serum creatinine level was 2.3, 1.4, and 2.5 mg/dL.

Conclusions. Laparoscopic nephron-sparing surgery is a feasible alternative to open partial nephrectomy and can be successfully applied to select patients with a pathologic renal artery.


Open partial nephrectomy for tumor is an established treatment for patients with impaired renal function or a compromised contralateral kidney.1 It is also increasingly used in patients with a small (4 cm or less) renal tumor in the presence of a normal contralateral kidney. Several minimally invasive nephron-sparing procedures have been devised in an attempt to minimize the operative morbidity while achieving comparable oncologic and functional outcomes.2,3 These techniques have used external energy sources (cryotherapy, radiofrequency) while leaving the thermoablated tissue in situ. Recently, laparoscopic partial nephrectomy has emerged as a viable nephron-sparing alternative, in which the established principles of open surgery are replicated. Laparoscopy offers the advantage of complete extirpation of the tumor, akin to open partial nephrectomy, while affording the advantages of a minimally invasive approach.4

As the ongoing experience with laparoscopic partial nephrectomy evolves, we are expanding the indications to include more technically challenging cases. We describe the initial experience with laparoscopic nephron-sparing surgery in the presence of a pathologic renal artery.

MATERIAL AND METHODS

Case 1
A 67-year-old woman presented with a 5-cm solid mass in a functionally solitary left kidney. Her past history included atrial fibrillation and multiple treatments for vasculopathy, including carotid endarterectomy, coronary artery bypass surgery, and percutaneous left renal arterial angioplasty and stent placement for renal artery stenosis. The baseline serum creatinine was elevated to 2.1 mg/dL (normal 0.7 to 1.4). Computed tomography revealed an atrophic, nonfunctioning right kidney and a 5-cm deeply infiltrating, broad-based, left lower pole tumor (Fig. 1). Various options were explained to the patient who elected to undergo laparoscopic partial nephrectomy.
Using a 5-port transperitoneal approach, Gerota’s fascia and perirenal fat were dissected off the renal surface, exposing the tumor with its overlying fat. Laparoscopic flexible ultrasonography confirmed that the intrarenal portion of the tumor extended up to the central sinus. Under real-time ultrasound control, the proposed line of circumferential parenchymal resection with an adequate margin of normal parenchyma was scored with J-hook electrocautery. The ultrasound probe was then placed over the renal hilum to determine where the Satinsky clamp could be positioned without traumatizing the renal arterial stent. Doppler imaging precisely identified the distal edge of the stent, the unstented normal distal main artery, and its first branching (Fig. 2). In this manner, we determined that the curved laparoscopic Satinsky clamp had to be placed precisely flush with the concave medial contour of the kidney to avoid crushing the stent. A Satinsky clamp with an exaggerated curve was selected (Aesculap, Center Valley), simulating the concavity of the renal parenchymal edge, to clamp the pedicle en bloc distal to the arterial stent. Under warm ischemia conditions, the tumor was excised along the previously scored line, achieving an adequate surgical margin. The pelvicaliceal system was suture repaired, and hemostatic renorrhaphy was performed. The laparoscopic Doppler probe was again placed over the hilum, and good blood flow across the renal artery and intact stent was confirmed.

**CASE 2**

A 56-year-old man presented with gross hematuria and serum creatinine of 1.0 mg/dL. An evaluation elsewhere had identified a right upper pole intrarenal mass on abdominal computed tomography. On performing three-dimensional computed tomography at our institution, the mass was considered to represent a calcified multilobular renal artery aneurysm. Selective right renal angiography confirmed the diagnosis of a trifoliated intraparenchymal aneurysm arising from a tortuous upper pole branch of the main renal artery (Fig. 3). After discussing the surgical options, the patient elected laparoscopic right upper pole partial nephrectomy.

Using a 5-port transperitoneal approach, Gerota’s fascia covering the upper renal pole was incised, exposing the renal parenchyma with the pulsating aneurysm. A laparoscopic flexible color Doppler probe was used to identify the primary feeding vessel to the aneurysm (Fig. 4). This vessel was circumferentially mobilized and transiently occluded with a laparoscopic bulldog clamp (MicroFrance, Quebec, Canada). Color Doppler ultrasonography confirmed the cessation of blood flow within the aneurysm. This feeding branch to the aneurysm was clipped and divided. A Satinsky clamp was used to obtain en bloc control of the main renal artery and vein. Cold cut scissors were used to excise the aneurysm, essentially performing an upper pole heminephrectomy.

**CASE 3**

A 66-year-old man with a history of severe atherosclerosis, abdominal aortic aneurysm, and bilateral renal artery stenosis had undergone aortobifemoral grafting and bilateral aortorenal bypass revascularization of both kidneys. A current mag-
Magnetic resonance imaging scan revealed a 2.2 × 2.5-cm enhancing exophytic mass located in the lateral aspect of a solitary functioning left kidney. The right kidney was found to be atrophic, with global parenchymal loss. The serum creatinine was 2.5 mg/dL, and the creatinine clearance was 36 mL/min. Various nephron-sparing surgical options were discussed with the patient, who selected laparoscopic partial nephrectomy.

After balloon dilation of the retroperitoneal space, the aortic graft and left renal vein were visualized. Careful exploration above and below the renal vein failed to identify the grafted renal artery. Furthermore, the perirenal fat was densely adherent, thick, and hemorrhagic, which precluded proper defatting of the kidney. Nevertheless, with intraoperative ultrasonography, the tumor was precisely localized and exposed. Because of these technical difficulties from postoperative adhesions, the decision was made not to perform partial nephrectomy, but to proceed with laparoscopic cryoablation as the safest form of nephron-sparing surgery for this patient with a solitary kidney. An additional 5-mm port was placed to insert the cryoprobe, which was punctured through the center of the tumor and its tip advanced to just beyond the deep edge of the tumor. Under real-time ultrasonographic control, a double freeze-thaw cycle was performed, ensuring that the ice ball circumferentially extended 1 cm beyond the visible tumor margin. After the second thaw, the cryoprobe was removed, and the argon beam coagulator was used to obtain hemostasis.

FIGURE 3. (A) Selective arteriogram showing trilobed aneurysm in upper pole of right kidney (black arrow). Supply of aneurysm emanated from enlarged, tortuous, upper pole arterial branch. (B) Three-dimensional computed tomography scan showing two large components of aneurysm. Posterior component measured 2.3 cm and anterior component 3.5 cm in maximal dimension (white arrow).

FIGURE 4. Color Doppler ultrasonography showing arterial blood jet within aneurysm (white arrow). (Inset) Surface of aneurysm and 10-mm flexible laparoscopic ultrasound Doppler probe.
RESULTS

Case 1

Complete excision of the tumor necessitated lower heminephrectomy, removing an estimated 50% of the kidney. The total operative time was 135 minutes, the warm ischemia time was 28 minutes, and the estimated blood loss was 50 mL. Ambulation and oral liquids were resumed by day 2. Her serum creatinine peaked at 3.4 mg/dL on postoperative day 2 and decreased to 2.3 mg/dL by postoperative day 7. The radionuclide renal scan on postoperative day 2 showed normal perfusion to the left kidney, with mildly delayed uptake suggestive of resolving acute tubular necrosis. The postoperative course was complicated by a recurrence of atrial fibrillation, which was controlled by fluid restriction and digoxin, and an acute episode of gout of the right foot. These medical issues were resolved conservatively, resulting in a hospital stay of 7 days. No surgical complications occurred. The pathologic examination revealed a 4.5-cm grade 3 clear cell renal cell carcinoma. The pT1 tumor did not infiltrate the perinephric fat, and a 1-cm negative surgical margin from the tumor was confirmed.

Case 2

The upper pole heminephrectomy resulted in excision of an estimated 30% of the renal parenchyma. The total operative time was 4 hours, including a warm ischemia time of 39 minutes. The estimated blood loss was 400 mL. No intraoperative complications occurred. The patient resumed ambulation and oral intake on postoperative day 1. His postoperative serum creatinine was 1.4 mg/dL. The postoperative course was uneventful, and the patient was discharged on day 4. Pathologic examination confirmed a calcified atherosclerotic intra-renal aneurysm.

Case 3

The total operating room time was 2.8 hours, the cryoaablation time was 27 minutes, and a 3.7-cm cryolesion was achieved. The blood loss was 100 mL. No perioperative complications occurred. His postoperative creatinine remained unchanged at 2.5 mg/dL. Magnetic resonance imaging on postoperative day 1 revealed a nonenhancing lesion consistent with a technically adequate cryoaablation. The hospital stay was 2 days. The pathologic examination of the precryoaablation biopsy cores taken during the procedure revealed Fuhrman grade 2 renal cell carcinoma. During a follow-up of 6 months, magnetic resonance imaging revealed gradual contraction of the cryolesion without evidence of enhancement.

COMMENT

Renal artery disease coexisting in patients with renal cell carcinoma is an infrequent event that poses unique management issues. When renal cell carcinoma and renal artery disease affect the same kidney in the presence of a normal contralateral kidney, radical nephrectomy is the preferred treatment. Hafez et al. defined the role of open partial and radical nephrectomy in a series of 48 patients with localized renal cell carcinoma and ipsilateral renal arterial pathologic features. The treatment was individualized for each patient. Partial nephrectomy was performed in 44 patients, and bilateral renal cancer operations were staged. Eleven patients underwent surgical vascular reconstruction with partial nephrectomy, and 2 patients underwent percutaneous transluminal angioplasty before tumor excision. The degree of arterial stenosis was only mildly or moderately severe in the remaining patients and thus did not require treatment. Postoperative follow-up showed preservation of renal function in 97.9% of the patients. This experience gave us the confidence that similar renal pathologic findings could be treated in a minimally invasive fashion.

Laparoscopic nephron-sparing surgery in the presence of renal arterial pathologic findings has not been previously reported. Regardless of tumor size and location, precise identification, dissection, and mobilization of the renal artery and branches involved is an advanced laparoscopic maneuver. Laparoscopic ultrasonography is essential during such cases to provide precise information regarding the location of the arterial pathologic features and appropriate achievement of renal hilar control. In the first case, a laparoscopic, flexible, steerable, ultrasound probe with B-mode and Doppler capability provided detailed information regarding the course of the renal artery and its major branches with respect to the intraluminal stent. A safe area, flush with the concave medial contour of the kidney, was selected for placement of the Satinsky clamp without jeopardizing stent integrity. The absence of calcification and significant plaque disease in the distal renal arterial tree was also confirmed. In the second case, color Doppler ultrasonography was used to locate definitively the feeding vessel to the aneurysm. After the kidney surface and the aneurysm were exposed, the upper pole branch was temporarily occluded with a laparoscopic bulldog clamp. However, color Doppler ultrasonography revealed uninterrupted blood flow within the aneurysm. Additional hilar dissection revealed another presumed feeding vessel to the aneurysm. Once again, a bulldog clamp was used to temporarily occlude this vessel. At that time, color Doppler ultrasonography demonstrated complete cessa-
tion of blood flow within the aneurysm. Thus, the real feeding branch to the aneurysm was correctly identified, clipped, and transected. In the third case, because of the orthotopic renal artery graft revascularization, severe postoperative adhesions in the renal hilum area were encountered. With careful dissection, we were able to identify the aortic graft and the main renal vein. Despite the use of duplex ultrasonography, we could not confidently ascertain the location of the grafted renal artery. Because the perirenal fat was extremely adherent to the renal capsule, we were unable to defat the kidney to localize the tumor. Real-time ultrasonography was used to precisely confirm the location and size of the tumor. Although in this case, we opted against laparoscopic partial nephrectomy, cryotherapy, another minimally invasive technique of nephron-sparing surgery, was used. Intraoperative ultrasonography confirmed that the ice ball extended approximately 1 cm beyond the tumor margin.

Clearly, advanced cases of partial nephrectomy potentially result in longer periods of warm ischemia because of the technical demands inherent in such cases. In this experience, renal hilum clamping was performed in 2 cases, with warm ischemia times of 28 and 39 minutes, respectively. We believe that the time-tested surgical principles of open partial nephrectomy offer the best chance of laparoscopic success. At this writing, a technique of kidney surface cooling with ice slush has been developed and tested at our institution. It is likely that the ability to achieve adequate cooling with ice slush laparoscopically may facilitate performance of even more complex laparoscopic partial nephrectomies.

CONCLUSIONS

We described the application of laparoscopic nephron-sparing surgery for advanced cases with concomitant renovascular disease. Gradually, the indications for this minimally invasive approach are expanding, making it an important addition to our armamentarium in the treatment of localized renal tumors. A prerequisite to success in such advanced cases is a team approach between skilled laparoscopic and radiologic teams, combined with careful patient selection.

REFERENCES