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LAPAROSCOPIC NEPHRECTOMY, EX VIVO EXCISION AND AUTOTRANSPLANTATION FOR COMPLEX RENAL TUMORS

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ABSTRACT

Purpose: In many patients partial nephrectomy is the preferred alternative to radical nephrectomy for upper urinary tract cancers. We describe the use of laparoscopic nephrectomy, *ex vivo* excision and reconstruction, and autotransplantation to expand the realm of minimally invasive, nephron sparing surgery to the most complex renal tumors.

Materials and Methods: In our cohort undergoing renal surgery 2 patients had a solitary kidney with renal tumors not considered amenable to *in situ* partial nephrectomy. After transperitoneal laparoscopic nephrectomy *ex vivo* tumor excision and renorrhaphy were performed. The kidney was transplanted to the ipsilateral iliac vessels through the Gibson extraction incision.

Results: Indications for surgery were high grade urothelial carcinoma within a caliceal diverticulum and a central 5 cm renal cell carcinoma. Mean nephrectomy, cold ischemic and transplantation times were 4.5, 2 and 3.7 hours, respectively. No intraoperative or postoperative complications were noted. Hospitalization was 12 and 6 days, respectively. At 20 and 12 months of followup each patient remained off dialysis without evidence of recurrence.

Conclusions: Despite experience with conventional nephron sparing surgery some cases may be more appropriate for *ex vivo* excision and reconstruction. In these situations the minimally invasive approach provides a kidney suitable for renal autotransplantation, while simultaneously decreasing patient morbidity. This novel approach to complex renal tumors is feasible when one applies principles of laparoscopic donor nephrectomy and possesses experience with renal transplantation.

KEY WORDS: kidney; kidney neoplasms; nephrectomy; laparoscopy; transplantation, autologous

Laparoscopic radical nephrectomy has become a viable option for suspected kidney malignancies.[1,2] Nevertheless, nephron sparing surgery may be preferable when feasible. Evidence suggests that cancer outcomes after partial nephrectomy are equivalent to those of radical nephrectomy with the advantage of decreasing renal insufficiency.[3–5] At most centers groups continue to perform open partial nephrectomy using the traditional extraperitoneal flank incision. Thus, unless laparoscopic partial nephrectomy is attempted, many patients with renal tumors do not benefit from modern minimally invasive techniques and the concomitant decrease in morbidity and convalescent time.

Clearly intended nephron sparing surgery is mandatory in a subset of patients with renal tumors, including those with bilateral masses or renal insufficiency. In the patient with a solitary kidney all efforts must be made to preserve normal parenchyma, while simultaneously removing the cancer. Large experience with open partial nephrectomy has allowed surgeons to successfully resect almost all lesions with the kidney *in situ*. Indeed, little has been published regarding bench renal surgery and autotransplantation in the last decade.[6]

We have gained significant experience with laparoscopic nephrectomy and subsequent transplantation for donation to those with renal failure and autotransplantation after severe ureteral injury.[7,8] Based on this we performed laparoscopic nephrectomy for intended *ex vivo* dissection and autotransplantation in patients with complex tumors of a solitary kidney.

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MATERIALS AND METHODS

Since November 1999, we have performed laparoscopic donor nephrectomy for allotransplantation in 326 patients without technical graft loss. In addition, we have performed laparoscopic nephrectomy and renal autotransplantation in 12 select patients with severe upper ureteral loss. Based on this experience we applied the techniques to 2 patients with complex renal tumors within a solitary kidney.

Briefly, we mark an ipsilateral Gibson incision prior to placing the patient in a modified lateral flank position. Pneumoperitoneum is established and the first radially dilating trocar is placed in the subcostal location at the lateral edge of the rectus abdominus muscle. An additional 3 trocars are placed in an L-shaped and reverse L-shaped configuration for the left and right sides, respectively. The colon and spleen/liver are mobilized medial by incising the lateral peritoneal reflection. The ureter is identified at the level of the iliac vessels, minimizing dissection of the tissue between the gonadal vein and the more lateral ureter. The hilum is exposed, and the vein and artery are isolated with vessel loops. A papaverine soaked sponge is used to minimize vasospasm during the division of lateral, posterior and inferior attachments using laparoscopic coagulating shears. In contrast to laparoscopic nephrectomy for benign conditions, care is taken to maintain Gerota's fascia and remove all perinephric fat with the kidney. Throughout the operation urine output is monitored and maintained with fluids, mannitol and furosemide. The previously marked incision is made and the rectus muscle is reflected medial but the peritoneum is left

intact. The ureter is divided after ligation with clips. Heparin sulfate is given intravenously prior to dividing the artery. The artery is ligated on the aorta side with a single Hem-o-lok clip (Week Closure Systems, Research Triangle Park, North Carolina) and a more proximal titanium clip, and divided sharply distal to the 2 clips. An Endo-TA stapler (United States Surgical Corp., Norwalk, Connecticut) (30 to 2.5 mm) is then placed across the vein as close to the vena cava as possible and the vein is cut distal with scissors. As with the renal artery, no clips or staples are left on the graft. Anticoagulation is reversed with protamine sulfate. The peritoneum is opened and a hand is placed through the Gibson incision to retrieve the kidney, which is placed in ice slush and perfused with preservation solution (University of Wisconsin solution with 1,000 U heparin per l).

Tumor excision is performed as previously described.[9] Intraoperative frozen sections are obtained to confirm negative margins. Transected vessels are suture ligated with 4-zero chromic sutures and openings in the collecting system are closed with 3-zero polyglycolic sutures. The renal capsule is reapproximated with 2-zero chromic suture over thrombin soaked gelatin bolsters.

The kidney is transplanted in the usual fashion to the external iliac artery and vein. Urinary drainage is achieved by ureteroneocystostomy or ureteroureterostomy over an internalized stent. A Foley catheter and perinephric drain are left in place until urinary leakage stops.

Case 1. A 67-year-old man had a history of urothelial cell carcinoma of the bladder and right renal pelvis, which was treated with multiple transurethral resections and nephroureterectomy, respectively. Subsequently superficial lesions of the left ureter developed, which were successfully managed endoscopically. Computerized tomography (CT) identified a 3 cm complex cystic mass of the mid kidney. However, no identifiable source for positive urinary cytology could be identified on bladder biopsy, retrograde pyelography or ureteroscopy. Continued surveillance for persistent positive cytology was made difficult by a distal ureteral stricture. These factors in conjunction with the cystic lesion prompted surgical intervention. He had no evidence of metastatic disease with a serum creatinine of 2.5 mg/dl. In addition to laparoscopic nephrectomy and autotransplantation, the remaining distal ureter was excised and urinary reconstruction consisted of ureteroneocystostomy.

Case 2. A 68-year-old woman underwent open left nephrectomy for pT2 renal cell carcinoma 18 years earlier. On surveillance CT a 5 cm central right renal mass was identified (fig. 1). She had no evidence of metastatic disease and was in excellent health with a serum creatinine of 1.2 mg/dl. She strongly wished to avoid dialysis. Her other options were surveillance and attempted open partial nephrectomy.

FIG. 1. Case 2. CT reveals 5 cm central mass in solitary right kidney.

RESULTS

In each case laparoscopic nephrectomy was completed successfully without complications. Excellent length and quality of the ureter, vein and artery were obtained. Each kidney flushed easily with the preservation solution. All perinephric fat was excised and sent separately for pathological analysis. Meticulous dissection was able to remove the lesions with negative surgical margins. Despite extensive involvement of the collecting system renorrhaphy was achieved with complete closure of the collecting system (fig. 2). No difficulties were noted during kidney transplantation.

Time for laparoscopic nephrectomy, tumor excision and transplantation was 5 and 4, 2 and 2, and 4 and 3.5 hours in cases 1 and 2, respectively. Peak serum creatinine after transplantation was 2.8 and 2.0 mg/dl, respectively, and neither patient required dialysis. Hospitalization was 12 and 6 days, and serum at last followup (20 and 12 months) was 3.0 and 1.4 mg/dl, respectively. Nuclear renography confirmed excellent renal perfusion without urinary obstruction.

Pathological examination revealed high grade urothelial cell carcinoma within a caliceal diverticulum (pT2) and carcinoma *in situ* in the distal ureter in case 1, and grade 2 clear cell renal carcinoma (5 cm, pT1b) in case 2. The 2 patients were without evidence of disease at 20 and 12 months, respectively.

DISCUSSION

In recent years the laparoscopic approach to radical nephrectomy has become almost standard with cancer outcomes similar to those of standard open radical nephrectomy but with improved morbidity and convalescence.[1,2,10,11] Contemporary long-term data on open partial nephrectomy suggest that the incidence of renal dysfunction is decreased by maximizing preservation of the renal parenchyma.[5] Therefore, in most patients with renal masses who are candidates for surgery the typical alternatives are laparoscopic radical nephrectomy and open partial nephrectomy.[12]

The evolution and widespread experience with open partial nephrectomy have permitted all except the most difficult tumors to be removed. Previously complex renal tumors necessitating partial nephrectomy have been managed by open radical nephrectomy and *ex vivo* kidney dissection. The reconstructed kidney was then autotransplanted into the ipsilateral pelvis. The concept of renal autotransplantation was introduced in 1963 and subsequently popularized primarily for renovascular disease.[6,13] The advantage of bench renal surgery is a bloodless field, allowing meticulous tumor excision and renorrhaphy without the constraints of ischemic time. Due to limitations, including increased morbidity and skill with vascular anastomoses, nephrectomy and autotransplantation are not commonly performed for renal tumors.

We recently reported our experience with laparoscopic nephrectomy and autotransplantation in patients with severe ureteral injuries.[7] Others have used the approach for ureteral tumors as well as loin pain-hematuria syndrome.[14–16] To our knowledge we report on the first 2 patients with renal tumors managed with laparoscopic kidney retrieval, *ex vivo* partial nephrectomy and autotransplantation. We believe

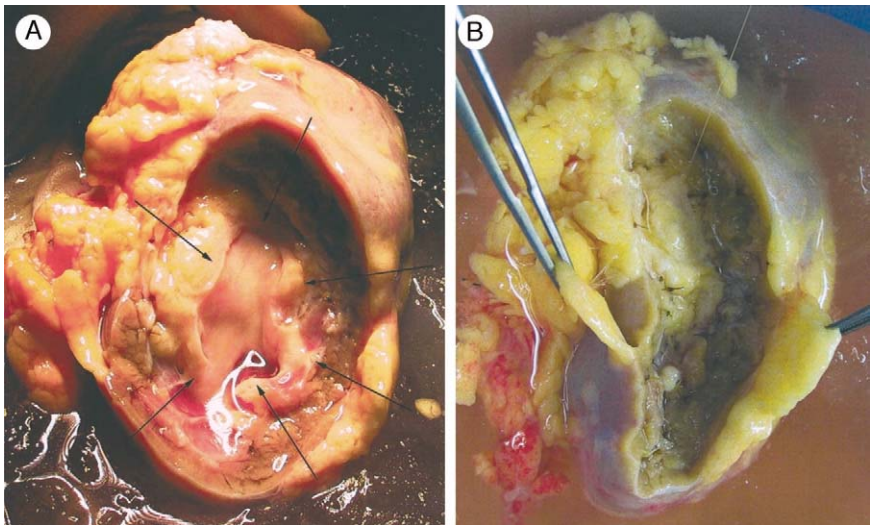

FIG. 2. Case 1. Intraoperative photograph demonstrates kidney appearance after excision of caliceal diverticulum and surrounding parenchyma (*A*), and collecting system closure (*B*). Arrows indicate opened collecting system edge. Subsequently renal capsule was reapproximated over gelatin bolsters prior to autotransplantation.

that there may be a role for this technique in the current treatment paradigm of renal masses. The 2 patients had complex renal masses within a solitary kidney. In each case the nature and location of the tumor would have made *in situ* dissection difficult. In case 1 preoperative imaging and endoscopy were unable to delineate clearly the extent of the caliceal diverticulum. In addition, the distal ureteral stricture and carcinoma *in situ* would not have been addressed by traditional *in situ* partial nephrectomy. In this patient we also eliminated the potential for *in vivo* cell tumor spillage and seeding. In case 2 the degree of identification and preservation of the intraparenchymal collecting and vascular systems would not have been possible with the kidney remaining in the retroperitoneum. The preservation of renal function, as demonstrated by serum creatinine and the avoidance of dialysis at intermediate followup, confirms the observations of Novick et al.[17] Even with a 50% or greater decrease in renal mass in a solitary kidney 86% of patients maintained stable renal function in that study. Careful monitoring was necessary to detect progressive proteinuria and glomerulosclerosis.

In our patients alternative approaches included attempted *in situ* partial nephrectomy, and planned radical nephrectomy and dialysis. Significant ischemic time would have been necessary for tumor excision and renorrhaphy, increasing the likelihood of acute tubular necrosis and temporary hemodialysis. Alternatively one could argue that complete kidney removal via laparoscopy would minimize morbidity as well as cancer recurrence. Despite the availability of renal replacement therapy nephron sparing in the older population remains desirable. 1) The waiting time for renal transplants is significant with more than 40% of patients on the list for more than 2 years.[18] With an underlying urinary malignancy it is suggested that transplantation and immunosuppression be delayed for at least 2 to 3 years. 2) Mortality on dialysis approaches 70% at 5 years in patients such as ours.[19] 3) Outcomes after transplantation in those older than 50 years are limited with calculated annual death rates of 61.3 to 119.9/1,000 patient-years at risk compared to 15.0 to 27.9 in patients 18 to 49 years old.[18] Thus, although cancer outcomes may be maximized with radical nephrectomy, overall survival is compromised with the need for prolonged dialysis or even successful renal transplantation.

Our renewed interest in *ex vivo* renal surgery and autotransplantation is stimulated by advances in minimally invasive techniques. We believe that the scope of nephron sparing surgery may be expanded with the option of laparoscopic nephrectomy. Although open nephrectomy remains an option for bench surgery, it is associated with increased morbidity. The combination of laparoscopic nephrectomy and autotransplantation may be advantageous not only for renal malignancies, but also for vascular reconstruction.

Several technical considerations deserve emphasis. 1) Experience with the standard laparoscopic donor operation is mandatory to ensure adequate graft and vessel quality. This is more crucial for the right kidney, in which the short, thin renal vein was problematic in early series. However, in contrast to typical donor nephrectomy, dissection should be carried outside of Gerota's fascia. 2) Meticulous *ex vivo* excision should preserve the collecting system as much as possible. Although reconstruction reapproximates the collecting system, urinary extravasation may be prolonged when extensive violation occurs. This situation can be managed expectantly with adequate renal/bladder and perirenal drainage. 3) The kidney inevitably bleeds after anastomosis and removal of the vascular clamps. Although the tendency may be to take down the reconstruction to place more sutures or identify the site of bleeding, we have successfully managed this situation by direct compression of the kidney.

CONCLUSIONS

We applied a minimally invasive approach to decrease morbidity and facilitate tumor excision in cases of complex renal tumors. Excellent outcomes were achieved with respect to convalescence, cancer control and the preservation of renal function. With the decrease in morbidity afforded by the laparoscopic approach greater consideration should be given to bench tumor removal and reconstruction when preservation of renal function is imperative.

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