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Renal Masses Herniating into the Hilum: Technical Considerations of the “Ball-Valve Phenomenon” During Nephron Sparing Surgery

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INTRODUCTION

Nephron sparing surgery (NSS) is a well-established standard for treating localized renal masses^{1–3}. For absolute, relative and even elective indications, partial nephrectomy offers excellent oncologic outcomes with less risk of resultant chronic kidney disease^{4–7}. Unfortunately, NSS remains nationally underutilized. Particularly, cases qualitatively deemed technically difficult, because of tumor location, are less likely to be selected for partial nephrectomy⁸.

Improved techniques and increased surgical experience have made it possible to resect even centrally located sinus tumors previously considered inappropriate for nephron sparing techniques. While several series have described similar oncologic outcomes for open or laparoscopic NSS on central versus peripheral masses, NSS for central tumors is more technically demanding and associated with increased ischemia times, increased blood loss, and an increased incidence of collecting system violation^{9–15}. This calculus leads to the unfortunate over utilization of laparoscopic radical nephrectomy for low risk or even benign localized hilar renal tumors.

The complexity of dissection and extent of hilar involvement of renal tumors is assessed preoperatively using CT scan and MRI. While these modalities have greatly improved early detection and pre-surgical planning, there is a tendency to eliminate the option of partial nephrectomy for truly hilar lesions. While there are many benefits of laparoscopic approaches for radical nephrectomy, the loss of additional nephrons may be unnecessary and has been shown to be associated with increased risk of chronic renal insufficiency and morbidity⁷. In addition, there is no consistent definition of what constitutes a hilar lesion and most studies of central renal lesions suffer from selection bias.

Here we describe the surgical technique of resecting renal tumors herniating into the renal sinus. We have observed the “ball-valve” phenomenon, as applied to central renal masses,

and define it as herniation of a renal mass arising from the parenchyma adjacent to or within the renal sinus. Recognition of this phenomenon is essential for successful open, laparoscopic or robotic reduction and resection of hilar renal masses. Here we describe our techniques utilized for nephron preservation in these cases.

SURGICAL TECHNIQUE AND METHODS

A review of the prospectively maintained kidney cancer database at our institution was performed to identify 36 lesions resected with nephron sparing techniques. These tumors had radiographic evidence of the tumor originating from the renal parenchyma within or adjacent to the renal sinus and herniating or “ball-valving” into the hilum. Patient characteristics are listed in Table 1.

All tumors were in a hilar location defined as contacting the renal sinus fat, renal artery, vein, and/or renal pelvis centrally on enhanced cross sectional imaging. All patients underwent clinical staging with review of CT and MRI imaging by the operating surgeon and a dedicated genitourinary radiologist. Pre-operative evaluation included standard history, laboratory testing, and radiographic lesion evaluation, including reformatted cross sectional images. Once renal tumor sinus herniation or “ball-valving” was identified (FIGURE 1), a nephron sparing approach with reduction of the herniated hilar tumor was performed. Regardless of approach (open, laparoscopic/robotic), tumor herniation was reduced in a similar fashion. Once the kidney is mobilized, all perinephric fat is removed to facilitate visualization of the entire capsular surface of the kidney and the concave parenchymal configuration of the hilar boundaries. The components of the renal hilum are then circumferentially dissected including first and second order vessels where appropriate. Intra-operative ultrasound (IOUS) is utilized to assess the depth and width of the tumor to assist with the planned resection. Importantly, a combination of preoperative cross sectional imaging (CT or MRI) and IOUS is used to identify the location of parenchymal origination of the tumor within the sinus. Dissection and reduction of the herniated tumor is performed before vascular clamping and begins in the renal sinus at the interface between the sinus fat and the lesion, using a Gil-Vernet approach. Once a plane of dissection has been developed, the space between the sinus fat and the tumor is packed tightly with Fibrillar (Ethicon, Somerville, NJ). This maneuver allows further reduction of the tumor out of the renal sinus, subsequently moving the tumor position into a more exophytic configuration. The parenchymal borders nearest the origin of the tumor are then scored using cautery, the vessels clamped and the tumor excised sharply off of the originating parenchyma in a standard fashion. The plane of dissection is continued medially toward the hilum until the Fibrillar packing is encountered. This technique prevents inadvertent entry into the hilar components, and provides the surgeon with a topographical reference needed to prevent a positive margin at the hilar boundary. Figures 2 and 3 illustrate the salient points of the technique.

The majority of the dissection, principally the reduction of the herniated tumor, is performed prior to vascular clamping to minimize ischemia time and limit the amount of normal parenchyma resected. In cases where the originating parenchyma that gives rise to the tumor is more posterior, a cap of anterior hilar parenchyma can be excised to unroof and thereby expose the central tumor. This maneuver generally necessitates a more complex collecting system/vascular dissection and repair.

RESULTS

Using these techniques, we were able to successfully perform complex NSS on 36 renal tumors herniating into the renal sinus, which were deemed inappropriate for NSS by

referring physicians. The series includes 15 patients with absolute indications for NSS (solitary kidney/bilateral tumors) in whom radical nephrectomy and institution of hemodialysis was recommended. Additionally, 13 patients had relative indications for NSS (significant chronic kidney disease) and two were re-operative partial nephrectomies. Median patient age was 67 (mean 64, range 33 to 84). The vast majority of the patients (89%, n=25) were male. None of the procedures were converted to radical nephrectomy. Five were performed using a minimally invasive (laparoscopic/robotic) approach and none require open conversion.

The renal lesions removed at surgery had a median size on pre-operative imaging of 3.5 cm (mean 5 cm, range 1 to 25cm). No patients were excluded from NSS based on size criteria. All, but one, margins were negative. A microfocal positive surgical margin was observed in a patient with high grade pT1b renal mass and a pre-operative GFR of 35cc/min. Median pre-operative creatinine was 1.3 mg/dL (mean 1.3, range 0.5–2.5) and median post-operative creatinine was 1.3 mg/dL (mean 1.4, range 0.5 to 2.5). No statistically significant change in GFR was observed following surgery (Mann Whitney test, $p=0.12$). Median estimated blood loss was 200 cc's (mean 231, range 50 to 1200). No patients required blood transfusion within 30 days of surgery. Median ischemia time was 36 minutes (mean 34.5, range 0 to 80). Six out of 36 (17%) lesions were benign. All patients had localized (pT1) tumors and 94% (34/36) were deemed pathologically "low risk" tumors. To date there have been no local tumor recurrences or progression to metastatic disease. Median follow up was 7 months (mean 12, range 0.75 to 51). Complications included four post-operative urinary leaks. There were managed conservatively. One of these patients also had a deep vein thrombosis, requiring anticoagulation with a subsequent perinephric hematoma and leak. Another patient with a urinary leak developed a pseudoaneurysm after an open partial nephrectomy and was successfully treated with embolization. One patient expired after developing acute respiratory distress syndrome likely secondary to aspiration. No patients required renal replacement or temporary dialysis.

DISCUSSION

NSS is an effective but underutilized treatment for localized renal masses.⁸ Treatment options for complex renal lesions are often presented to patients based on radiographic imaging, a qualitative evaluation of a tumor's location and an individual surgeon's experience and comfort level. It is important to emphasize that pre-operative radiographic studies evaluating hilar renal tumors must be interpreted carefully. Recognition of herniation or "ball valving" of the hilar tumor is critical before summarily dismissing the possibility of NSS. Once recognized, the anatomy of the ball-valved tumor in relationship with other vital hilar structures (vasculature and collecting system) must either be mentally reconstructed or graphically reformatted in 3-dimensions.¹⁶ The subsequent decision as to the best nephron sparing approach (open, laparoscopic or robotic) can then be reached. The perceived technical demands of laparoscopic suturing for collecting system entry and risk of vascular injury will often deter less experienced laparoscopists from nephron sparing. Moreover, the push for laparoscopy, stemming from both the surgeon's and the patient's motivations, often inappropriately results in small and localized hilar lesions being treated with laparoscopic radical nephrectomy. We believe this is an inappropriate trade off. Sacrifice of uninvolved renal parenchyma and subsequent risk of chronic kidney disease is unjustified.⁷ While there are reports of excellent surgical and oncologic outcomes from laparoscopic NSS literature, lack of advanced MIS or open surgical skills should not default to the patient receiving minimally-invasive yet nephron-wasting surgery^{7,14,17}. Moreover, utilization of safe and effective surgical techniques to remove the ball-valved sinus tumor without sacrifice of uninvolved parenchyma or compromise of oncological principles is attainable using the

open or laparoscopic/robotic approaches, as long as this anatomical phenomenon is radiographically understood and identified.

Recent studies suggest that the majority of incidental small renal masses are pathologically low risk. Indeed, more than 80% of renal carcinomas <4cm in size are of low nuclear grade.^{18,19} As such, we believe the default surgical procedure for these lesions is partial nephrectomy. Recognition of renal sinus tumor herniation -- “ball valving” of the tumor into the sinus -- allows for safe open or minimally invasive surgery and maximal nephron preservation.

CONCLUSION

Recognition of the tendency for hilar renal parenchymal masses to “ball-valve” or herniate into the renal sinus is essential when planning NSS for complex central lesions. Intra-operative reduction of the herniated mass is possible, once this phenomenon is appreciated. Using the techniques described here, we have demonstrated success using open, laparoscopic and robotic approaches for ball-valving lesions. Minimal intra-operative complications and favorable post-operative outcomes were achieved.

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Figure 1. Axial cut of a computed tomography scan of a patient with bilateral renal masses. The left mass arises from the anterior aspect of the kidney and herniates into the renal sinus, illustrating the “ball valve” phenomenon.

Figure 2.

Illustration summarizes the salient points of the technique to first reduce and then resect “ball-valving” tumors that herniate into the renal sinus. Intra-operative ultrasound is utilized to assess the depth and width of the tumor to assist with the planned resection. The plane between the tumor and the renal sinus fat is developed; the tumor is reduced; and the resulting space is packed tightly with a hemostatic agent such as Fibrillar (Ethicon, Somerville, NJ). The hilar vessels are then clamped, and the tumor is excised sharply off of the originating parenchyma. Fibrillar provides the surgeon with a topographical landmark for the medial boundary of the dissection and prevents inadvertent entry into the hilar structures.

Figure 3.

Panel (A): Axial cut from a contrast-enhanced CT scan of a 64 year-old male with a solitary left kidney and a history of multiple prior abdominal surgeries. The arrow indicates the direction of rotation required to reduce the herniated tumor from the renal sinus during partial nephrectomy. Panel (B): Intra-operative photograph following tumor resection. The renal pelvis (*), infundibulum, and calyces are visible after the herniated tumor is reduced and resected from the sinus.

Table 1

Patient Characteristics.

	All patients
No. Patients	36
Mean age (yrs.), range	64 (33 to 84)
No. men (%)	32 (89)
No. women (%)	4 (11)
No. previous renal surgery	7 (30)
No. patients with solitary kidneys (%)	5 (14)
No. patients with bilateral lesions (%)	10 (28)