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Case report and review

Transperitoneal laparoscopic partial nephrectomy for renal cell carcinoma in a horseshoe kidney. Case report and review

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Abstract. Horseshoe kidney represents the most common renal fusion anomaly, with an incidence of 1 in 400. It comprises multiple anatomical abnormalities which favor complications such as hydronephrosis, renal calculi formation and a twofold risk of Wilms tumor. Renal cell carcinoma equates for approximately 50% of tumors reported in cases with horseshoe kidney, with the same incidence and prognosis as in the general population. Surgical management, preferably through laparoscopic approach, is the treatment of election in case of localized or locally advanced oncologic disease. In case of T1 tumors, partial nephrectomy ensures similar oncologic outcomes as radical nephrectomy, with significant renal functional preservation. We report a case of an asymptomatic 62-year-old male diagnosed with a 54-mm tumor in the right moiety of a horseshoe kidney. After thorough preoperative planning, the patient underwent transperitoneal laparoscopic partial nephrectomy with complete excision of the tumor, that was later diagnosed as renal cell carcinoma. To our knowledge, there have only been 9 other reported cases of laparoscopic partial nephrectomy in a horseshoe kidney. Albeit a challenging surgical situation, a laparoscopic approach is a feasible therapeutic option in such cases.

Key Words: Horseshoe kidney, Renal cell carcinoma, Laparoscopic partial nephrectomy, Tridimensional Reconstruction

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Introduction

Described for the first time in medical literature in 1522 by di Capri, horseshoe kidney represents the most common renal fusion anomaly, with an incidence of 1 in 400 (0,25% of the population) (Wein et al 2020, Bendir et al 2014). Horseshoe kidney has a predilection for males (2:1) and appears more often in chromosomal aneuploidies (trisomies 20% and Turner syndrome 60%) (Wein et al 2020, Bendir et al 2014).

The anomaly occurs during the sixth week of gestation due to the fusion of the metanephric blastema through an isthmus bridging most commonly (90%) the lower renal poles, located anteriorly to the aorta and the vena cava (Harris et al 2000). The presence of the isthmus blocks the physiological rotation of the kidney, thus the calyx are oriented posteriorly, and the axis of the renal pelvis is oriented vertically or diagonal in the lateral plane (Wein et al 2020). This malformation favors the occurrence of pyeloureteral junction syndrome with subsequent development of secondary hydronephrosis and renal calculi (Bendir et al 2020).

Horseshoe kidney is also marked by great vascular heterogeneity, with only 5-30% of patients presenting only one renal artery and vein for each moiety (Wein et al 2020). The arterial supply of the isthmus can be provided through either one or both renal arteries or directly from the aorta through branches originating from below or above the renal isthmus (Wein et al 2020). There are also reported cases in which the artery of the isthmus stems from the inferior mesenteric artery, from the common or external iliac artery or from the sacral arteries (Wein et al 2020). From an oncological standpoint, the risk for Wilms tumor is twofold in case of a horseshoe kidney (Mesrobian et al 1985). On the other hand, renal cell carcinoma equates for approximately 50% of tumors reported in cases with horseshoe kidney, with the same incidence and prognosis as in the general population (Nikoleishvili et al 2017).

In spite of any associated renal malformations, surgical management is the treatment of election in case of localized or locally advanced oncologic disease. The European Association of Urology recommends surgical treatment through laparoscopic approach wherever the experience of the surgeon allows it (Ljungberg et al 2021).

It has been demonstrated that in case of T1 tumors, partial nephrectomy ensures similar oncologic outcomes as radical nephrectomy, with improved function parameters and quality of life post-operatively (Shao et al 2020).

From a technical standpoint, oncologic surgery for cases associated with horseshoe kidney is considered difficult due to the

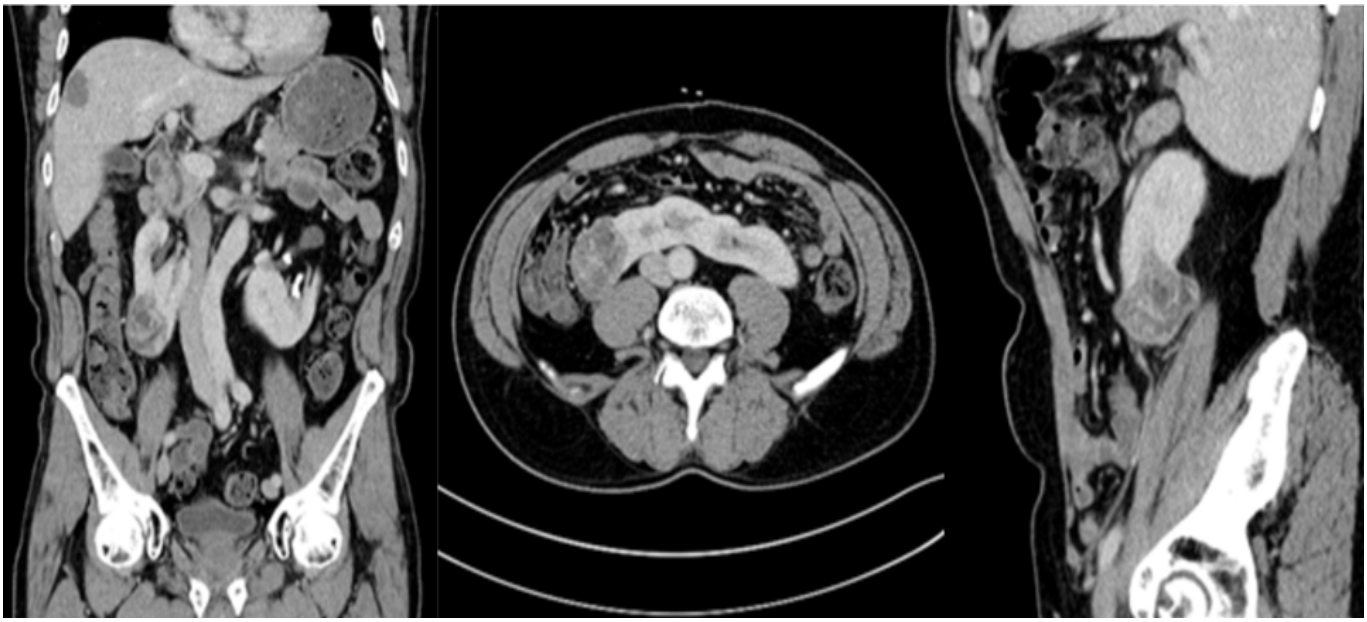

Figure 1. Contrast enhanced abdominopelvic CT in venous phase. Coronal reconstruction (left), axial reconstruction (middle), sagittal reconstruction (right) showing a 54/43/51-mm mass in the right moiety.

aforementioned anatomical abnormalities. Careful consideration must be given to the patient's pre-operative imaging studies. Tridimensional reconstructions can also provide valuable information regarding the local and vascular anatomy (Raison et al 2016). It should be also noted that in cases of partial nephrectomy, even after arterial clamping, the kidney is still supplied by the other moiety (Rasion et al 2016).

Laparoscopic approach can either be transperitoneal or retroperitoneal. The retroperitoneal approach proves to be essential in cases with a posterior renal tumor, because the presence of the isthmus does not allow traditional mobilization and flipping of the kidney and can offer better access to the renal arteries (Yang et al 2014). On the other hand, a transperitoneal approach can offer a much larger work space, decreasing the occurrence of conflicts between instruments and providing an easier access to the large vessels of the abdomen.

In this report, we describe the case of a transperitoneal laparoscopic partial nephrectomy for a T1b renal tumor in the right moiety of a horseshoe kidney and we offer a literature review of the other cases that underwent laparoscopic partial nephrectomy for solid renal masses in horseshoe kidneys.

Case presentation

A solid tumor in the right moiety of a horseshoe kidney was incidentally found during routine imaging studies in a 62-year-old man known with Parkinson's disease, arterial hypertension, chronic ischemic cardiopathy. Clinically, the patient is asymptomatic.

Contrast enhanced computer tomography (CT) revealed a horseshoe kidney of normal size and structure with unobstructive renal calculi in both collecting systems. A 54-mm enhancing lower-pole, anteriorly located mass was found in the right moiety of the horseshoe kidney. The tumor was limited to the kidney, with no evidence of invasion in the renal collecting system (Figure 1). For a better visualization of the local anatomy, a 3D reconstruction was performed, revealing two right renal arteries (Figure 2).

After thorough urologic and oncologic evaluation, the renal mass was staged cT1bN0M0 with a PADUA score of 10. The case was reviewed by the clinic's Uro-oncologic board of specialists and a laparoscopic partial nephrectomy was decided to be proposed to the patient.

Initially, under general anesthesia, ureteral stents were placed bilaterally with fluoroscopic guidance in order to improve ureteral drainage and reduce the chances of either a urinary fistula or a post-operative renal colic. Immediately after, the patient was placed in a flank position and trasperitoneal access was established through 5 laparoscopy ports. The right fascia of Told was incised, followed by dissection and medial reflection of the ascending colon. The lateral border of the right moiety was dissected and the renal tumor was identified (Figure 3).

Dissection of the right hilum was performed, with identification and isolation of the two right renal arteries. Because of tumor characteristics, tumor enucleation without ischemia was first attempted (Figure 4).

During the enucleation of the tumor, due to significant bleeding from the renal parenchyma, continuation of the procedure with warm ischemia time was decided. Bulldog clamps were placed on both right renal arteries and the resection of the tumor was completed, followed by internal and external renoraphy with Vicryl 1 suture secured with Hem-o-Lok clips (Weck Closure Systems, Research Triangle Park, NC, USA) with a total warm ischemia time of 24 minutes. Hemostatic material was applied and following the unclamping of the arteries, no signs of bleeding at the level of the suture were sighted (Figure 5).

The specimen was extracted inside an endobag through a small Pfannenstiel incision in the right iliac fossa and a drain was left in place. Total operative time was 290 minutes.

Postoperative evolution was favorable with the removal of the drain on day 4 and the patient was discharged uneventfully on day 6.

The pathologic examination of the specimen confirmed the presence of a clear-cell renal cell carcinoma with macrocystic pattern Fuhrman II, ISUP 2 with negative surgical margins and no

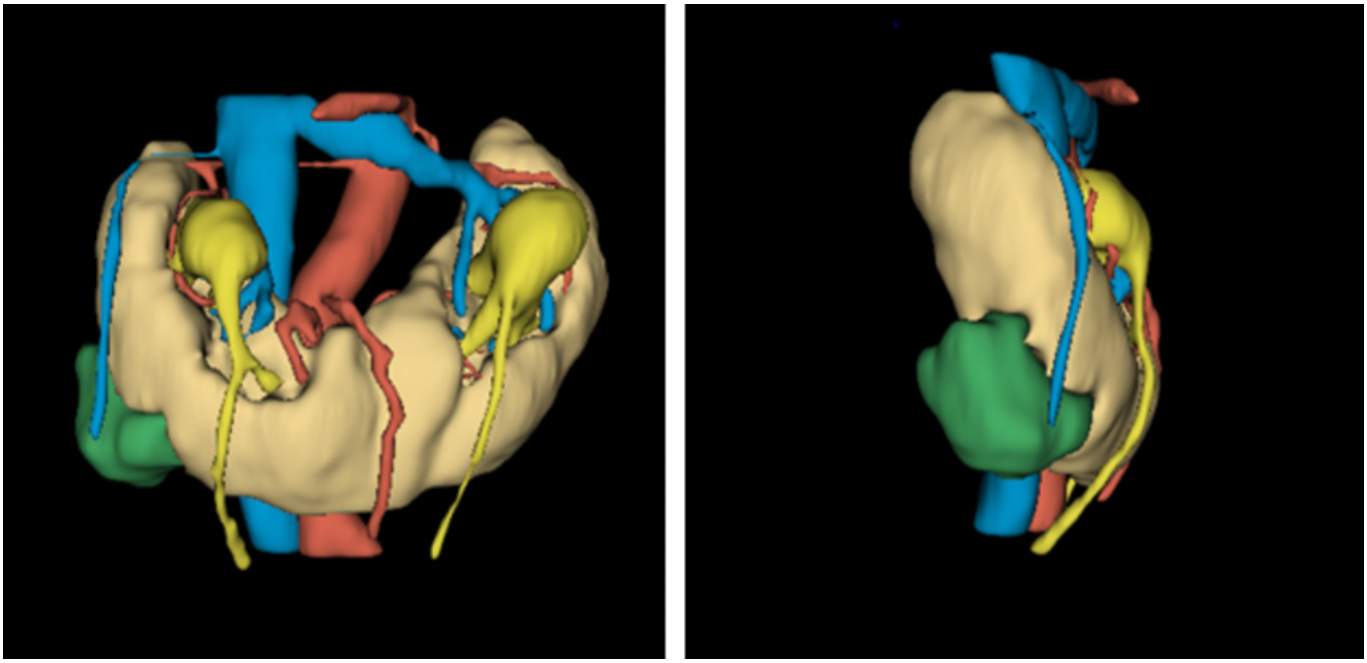

Figure 2. 3D reconstruction of the CT scan viewed in coronal plane (left) and sagittal plane (right) showing the kidney, the renal mass (green), the arterial (red) and venous (blue) vascularization and the urinary collecting system (bright yellow)

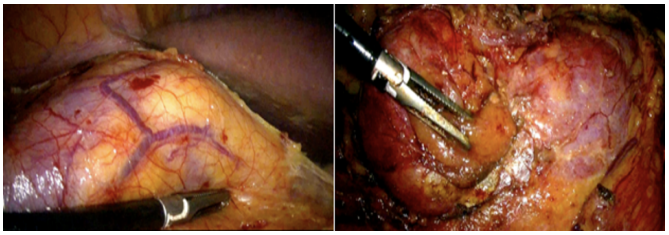

Figure 3. Exposure the renal surface after medial reflection of the ascending colon (left) and tumor exposure after dissection of the right renal fascia (right)

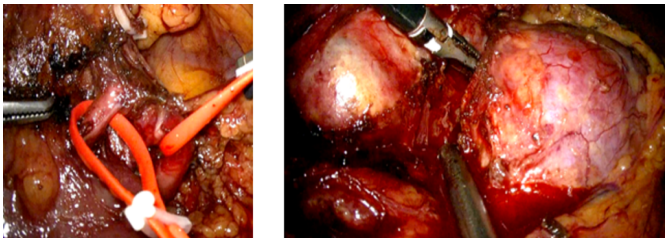

Figure 4. Isolation of the two right renal arteries (left) and tumor enucleation (right)

signs of venous extension, lymphatic invasion nor perineural infiltration (pT1bNxMxL0V0R0).

Discussions

To our knowledge, only nine cases of laparoscopic partial nephrectomy for horseshoe kidney tumors have been published in the literature until now (Tabel 1).

In the past, most tumors involving kidneys with fusion anomalies were treated by open radical heminephrectomy or partial nephrectomy (Nikoloeishvili et al 2017). With the advent of minimally invasive surgery, laparoscopic surgery started to replace open surgery.

The first case of laparoscopic partial nephrectomy for a horseshoe kidney tumor was published by Molina and Gill in 2003

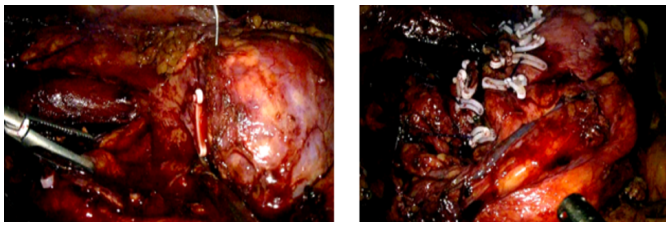

Figure 5. Tumor bed after tumor resection (left) and post-renoraphy aspect (right)

(Molina et al 2003), demonstrated that minimal invasive surgery is feasible even in case of a malformed kidney. The other aforementioned cases (Bendir et al 2014, Harris et al 2000, Shao et al 2020, Molina et al 2003, Tsivian et al 2007, Lee et al 2011, Ohtake et al 2018, Zhang et al 2019) further attest this claim.

In our case and four other cases, the surgery was performed transperitoneally and the other half via a retroperitoneal approach. For their case, Molina and Gill decided on a retroperitoneal approach but mentioned that a transperitoneal approach would be best suited for a renal tumor located anterior and anterolaterally. Even though a retroperitoneal approach would enable easy access to the renal artery (Raison et al 2016), for our case we opted for a transperitoneal approach due to the tumor location and for the added benefit of a larger intra-abdominal workspace.

Due to the presence of bilateral renal calculi and in order to reduce the risk of a urinary fistulae, we decided to perform bilateral ureteral stenting prior to surgery, thus optimizing the urinary drainage of the kidneys. The same approach was carried out by Molina and Gill (2003), while Shao et al (2020) decided not to place a ureteral catheter, which complicated the intraoperative search for the ureter.

In the majority of reported cases, the resected tumor was later diagnosed by the pathologist as renal cell carcinoma, which is the most frequent type of renal cancer in both general population and in patients with horseshoe kidney.

Table 1. Summary of literature. NR: Not reported; RCC: renal cell carcinoma; R-LPN: Retroperitoneal laparoscopic partial nephrectomy; T-LPN: Transperitoneal laparoscopic partial nephrectomy; WIT: Warm ischemia time

Author	Age (years)	Sex	Side	Size (cm)	Surgery	Operating time (min)	Blood loss (mL)	WIT (min)	Pathology
Molina et al 2003	68	M	R	2	R-LPN	198	100	31	Hemorrhagic cyst
Tsivian et al 2007	62	F	R	2	T-LPN	210	70	NR	Oncocytoma
Lee et al 2001	21	F	L	4	R-LPN	186	490	28	Metanephric adenoma
Bendir et al 2014	58	M	R	4	T-LPN	180	200	25	RCC
Nikolei-shvili et al 2017	69	M	L	4,8	R-LPN	156	75	24	RCC
Ohtake et al 2018	83	F	L	2	T-LPN	159	NR	11	RCC
Zhang et al 2019	55	F	L	3	R-LPN	120	200	28	RCC
Zhang et al 2019	50	M	L	3,4	R-LPN	225	350	28	RCC
Shao et al 2020	65	M	L	4	T-LPN	210	800	30	RCC
Present case	62	M	R	5,4	T-LPN	290	100	24	RCC

In our case, tumor enucleation without ischemia was first attempted, but we abandoned this approach due to significant bleeding and decided to perform instead resection with minimal renal ischemia. Another possible approach would be to perform tumor enucleation after supraselective arterial embolization in order to prevent bleeding and facilitate the enucleation, with minimal loss of functional tissue (Kim et al 2005).

Another therapeutic approach that can be proposed to patients with small renal tumors would be ablative therapy through different methods: cryoablation, radiofrequency ablation, microwave ablation. Ablative therapy is best suited in case of frail patients or patients with multiple comorbidities (Ljungberg et al 2021). The presence of a renal malformation such as horseshoe kidney, that could complicate the surgical approach, might serve as an additional argument to offer ablative therapy as an alternative to surgery, even for cases that are staged T1b (Shapiro et al 2020).

In order to optimize our preoperative planning, we requested a tridimensional reconstruction of the patient's CT-scans, which offered a new perspective regarding the localization of the tumor and renal vascularization (number and course of renal arteries). Recent advancements in medical imaging, in particular Hyper-Accuracy 3D reconstruction (HA3D) and intraoperative augmented reality navigation were implemented in cases of complex renal tumors treated with augmented reality robotic-assisted partial nephrectomies (AR-RAPN) (Porpiglia et al 2020). When compared to ultrasound guided resection, the result was an improvement of the quality of the tumor resection phase and a reduction in postoperative complications with a better functional recovery (Porpiglia et al 2020). In the near future, we believe that these hybrid techniques will become more widely available, especially for partial nephrectomies in cases with complex renal masses or complicated local anatomy.

Conclusion

Due to distinct anatomical traits such as variable vascularization, abnormal positioning and orientation of the kidney and the presence of the isthmus, oncological surgery performed on a horseshoe kidney proves to be challenging from a technical standpoint.

Our case along with the above-mentioned series of published cases have established that a purely laparoscopic approach is feasible in case of partial nephrectomies for tumors in horseshoe kidneys.

Such cases should be treated in an individualized manner, with thorough preoperative planning based on imaging studies, as well as tridimensional reconstructions.

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