Robotic-assisted Laparoscopic Partial Nephrectomy in a Horseshoe Kidney. A Case Report and Review of the Literature

Avi Raman, Teele Kuusk, Eoin R. Hyde, Lorenz U. Berger, Axel Bex, and Faiz Mumtaz

Horseshoe kidney is a rare renal fusion anomaly, and because of limited mobilization of the kidney and its multiple arterial blood supplies, minimally invasive surgery for renal tumors can be challenging. We describe a case of a right-side oncocytoma in a horseshoe kidney managed robotically and review the literature of robotic-assisted laparoscopic surgical resection of kidney tumors in renal fusion anomalies. Robotic-assisted laparoscopic partial nephrectomy in a horseshoe kidney is feasible. Fusion-related limited mobility during the procedure, as well as an extremely variable blood supply, require meticulous planning. Multi-phase computed tomography and interactive 3D anatomical models are helpful tools to prepare for surgery. UROLOGY 114: e3–e5, 2018. © 2017 Elsevier Inc.

Horseshoe kidney is a renal fusion anomaly often associated with ureteropelvic junction obstruction found in about 0.15% to 0.25% of the population. Advanced minimally invasive surgical reconstructive techniques including laparoscopic and robotic-assisted approaches are increasingly applied in this population. Currently, some 20 cases of robotic reconstruction in horseshoe kidneys have been reported, including pyeloplasties, pyelolithotomies, and isthmusectomies.[1-10] Renal tumors associated with a horseshoe kidney have been described in fewer than 200 cases. Incidence and prognosis of renal masses seem to be not different from those of the general population. Contrary to the benign cases when laparoscopic or robotic-assisted anterior access to the upper ureter and the isthmus can be applied, partial or heminephrectomy for malignant renal tumors can be challenging. Difficulty of the procedure depends on the location of the mass, limited mobilization of the fused kidney, and its multiple arterial blood supplies. Five cases of laparoscopic partial nephrectomies have been published[11] and only 2 cases of robotic-assisted heminephrectomies.[12,13] We describe a case with 3D reconstruction of a right-side oncocytoma in a horseshoe kidney managed robotically and review the literature of robotic-assisted laparoscopic surgical resection of kidney tumors in renal fusion anomalies.

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From the Department of Urology, Royal Free Hospital, London, United Kingdom; the Department of Urology, The Netherlands Cancer Institute, Amsterdam, The Netherlands; the Translational Imaging Group, University College London, London, United Kingdom; and Innersight Labs Ltd, London, United Kingdom

Address correspondence to: Faiz Mumtaz, M.D., F.R.C.S., Department of Urology, Royal Free Hospital, Pond St, Hamstead, London, NW3 2QG, UK. E-mail: faiz.mumtaz@nhs.net

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CASE

A 53-year-old female patient was diagnosed with a right 3-cm cT1aN0M0 renal lower pole tumor in a horseshoe kidney (Fig. 1). She refused a biopsy and underwent robotic-assisted laparoscopic partial nephrectomy. Preoperative planning involved computed tomography (CT) of the abdomen, which allowed selective clamping (Fig. 2) and on which 3D reconstructions were based. Skin-to-skin time of the procedure was 170 minutes, and console time was 120 minutes. Blood loss was 150 mL, and hospital stay was 2 days. Histopathology revealed an oncocytoma. The patient developed no postoperative complications.

DISCUSSION

To date, only 2 cases of robotic-assisted partial or heminephrectomy for renal tumors in fusion anomalies of the kidney have been described in the literature.[12,13] One of these reports regarded an L-shaped fused crossed ectopia to the right (Table 1).[13] The variable blood supply, limited mobilization of the fused kidney, and the isthmus make any laparoscopic attempt for partial nephrectomy challenging. Five cases of trans- or retroperitoneal partial nephrectomies for horseshoe renal tumors 2-4.8 cm in diameter have been published and reviewed in the literature with surgery times of 156-210 minutes and warm ischemia times of 24-31 minutes.[11] No major complications were reported. This is in contrast to a retrospective study of 9 patients with tumors with a median size of 4.8 cm treated at a single tertiary care institution for tumors involving kidneys with fusion anomalies in which the surgical complications included 3 major (Clavien grade ≥ 3) and 3 minor (Clavien grade ≤ 2) complications.[14] However, the majority of these patients (n = 7) were treated with open partial nephrectomy.

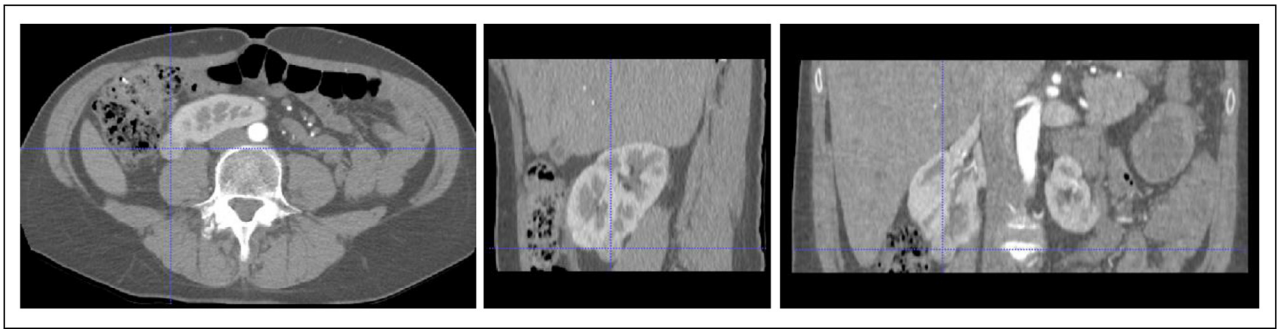

Figure 1. Cross-sectional contrast-enhanced CT axial, sagittal, and coronal images acquired at the arterial phase. Tumor location in each image is indicated by the blue crosshair.

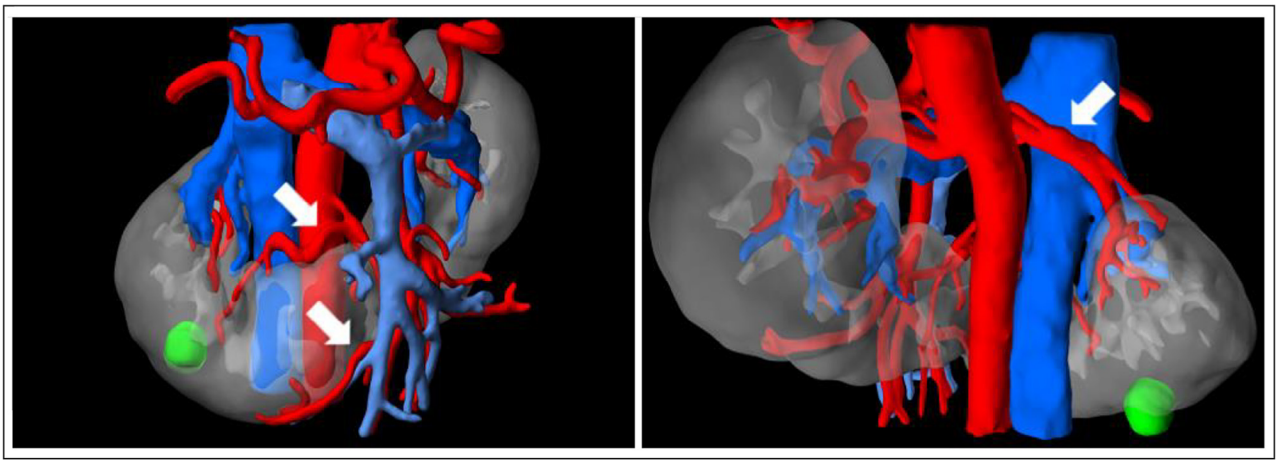

Figure 2. Three-dimensional model of the patient's renal system, indicating the spatial relationship of the horseshoe kidney (transparent gray), tumor (green), aorta (red), inferior vena cava (dark blue), and the portal vein (light blue). **(Left)** Anterior view showing the selective clamping sites (white arrows). **(Right)** Posterior view showing a major renal artery that was not clamped during the excision, thereby minimizing the hypoperfused region. The interactive model can be accessed using this link: http://innersightlabs.com/view/model-db118.html.

Table 1. Cases of robotic-assisted partial or heminephrectomy for renal tumors in fusion anomalies of the kidney

Author	Year	Side	Size Primary	TNM	Subtype	Surgery Time (min)	WITmin	Blood Loss	Procedure
Rogers	2008	Left	11 cm	pT3bN0Mx	Clear-cell	190	N/A	450	Robotic-assisted heminephrectomy, cavotomy, and thrombectomy
Kumar	2015	Right	18 cm	pT2bN0Mx	Chromophobe	120	N/A	600	Robotic-assisted heminephrectomy
The present case	2017	Right	3 cm	pT1aN0Mx	Oncocytoma	170	*13	<150	Robotic-assisted partial nephrectomy

TNM, tumor, nodes, metastases; WITmin, warm ischemia time in minutes.
* Selective clamping on 2 distal accessory arteries.

Therefore, it is of importance to demonstrate that the major steps of an open approach to renal tumors in fused kidneys can be performed laparoscopically. Recent prospective cohort studies and systematic reviews suggest superiority of robotic over laparoscopic partial nephrectomies.[15,16] Our case and the previous reports suggest that the robotic approach is ideally suited for identifying important structures after detailed preoperative radiological evaluation. Knowledge of the vasculature, location, and depth of the tumor, and proper surgical planning are essential in horseshoe kidneys and fused ectopias. Developed medical imaging technology can further aid the surgeon to best understand the complex horseshoe vasculature by the construction of interactive 3D anatomical models.[17] A medical

imaging service provider (Innersight Labs Ltd, London, UK) applied their bespoke machine learning image segmentation algorithm to the available, anonymized preoperative CT scans to construct such a model. In conjunction with the original CT scans, the 3D model allows the surgeon to view the patient anatomy from any angle, and unlike volume rendering, which can only be applied to a single scan at a time, the 3D model displays information from all available scans simultaneously; that is, arterial, venous, and excretory system information can all be viewed at once. Moreover, the semantic knowledge acquired during the image segmentation process means that the surgeon can selectively alter the surface transparency of any model object, allowing for the rapid assessment of vessel and tumor depth within the kidney.

CONCLUSION

Robotic-assisted laparoscopic partial nephrectomy in a horseshoe kidney is feasible procedure, and interactive 3D anatomical model images and printed models can be helpful tools for preoperative planning.

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