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Case Report

Robot-assisted laparoscopic partial nephrectomy for horseshoe kidney: A case report

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Abbreviations & Acronyms
3D = three-dimensional
CT = computed tomography
HSK = horseshoe kidney
IMA = inferior mesenteric artery
RAPN = robot-assisted laparoscopic partial nephrectomy
RCC = renal cell carcinoma
WIT = warm ischemia time

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Introduction: Horseshoe kidney has unique anatomical features, such as a complex blood supply. We report a patient with renal cell carcinoma in a horseshoe kidney, who underwent tumor resection by robot-assisted laparoscopic partial nephrectomy based on preoperative three-dimensional computed tomography.
Case presentation: A 66-year-old man was referred to our hospital with a 2-cm enhancing mid-pole mass in the left moiety of a horseshoe kidney. The clinical diagnosis was renal cell carcinoma cT1aN0M0 (R.E.N.A.L. nephrometry score: 1 + 2 + 3 + 3 = 9p). Robot-assisted laparoscopic partial nephrectomy was performed with selective clamping based on reconstructed three-dimensional images. The warm ischemia time was 13 min. Pathologic examination confirmed a diagnosis of pT1a clear cell renal cell carcinoma with negative surgical margins. At 6 months postoperatively, computed tomography showed no local recurrence or metastasis and renal function was intact.
Conclusion: Robot-assisted laparoscopic partial nephrectomy with preoperative three-dimensional computed tomography may have advantages for resection of tumors in patients with horseshoe kidney.

Key words: horseshoe kidney, renal cell carcinoma, robot-assisted laparoscopic partial nephrectomy.

Keynote message

Performing partial nephrectomy poses certain challenges in patients with HSK, including variability of the vascular anatomy, difficulty in mobilizing the fused kidney, and abnormal anatomy of the kidneys and adjacent structures. Preoperative imaging to visualize the complex anatomy of HSK is very important. In HSK patients who require RAPN, preoperative 3D imaging may improve both preoperative planning and intraoperative navigation during tumor resection.

Introduction

The ability to perform nephron-sparing surgery in patients with renal tumors has increased recently with the growing availability of robot-assisted surgery. Use of RAPN has been reported for complicated tumors, such as large renal masses, hilar tumors, and tumors associated with venous thrombosis.[1–3]

HSK is one of the most common congenital urologic anomalies. It is found in about 0.15% to 0.25% of the population,[4] and is twice as frequent in males as in females.[5] HSK has certain unique anatomical features. The most pertinent characteristics for surgeons to consider are marked variability of the renal vessels and abnormalities of the collecting system,[6] which can make surgical treatment of RCC technically challenging in patients with HSK.

Here, we report a patient with a small renal mass arising in a HSK, which was successfully resected by RAPN combined with preoperative 3D CT.

Case presentation

A 66-year-old man with HSK presented to our hospital because a 2-cm mid-pole tumor was incidentally found on magnetic resonance imaging in the posterior part of the left moiety of the fused kidney. He had no relevant medical history and no family history of RCC. No significant abnormalities were detected by laboratory tests and urinalysis.

CT scanning was performed with contrast medium, revealing a 2-cm enhancing mid-pole mass located posteriorly in the left moiety of the HSK (Fig. 1). From these findings, we made a clinical diagnosis of clear cell RCC cT1aN0M0 (R.E.N.A.L. nephrometry score: 1 + 2 + 3 + 3 = 9p). Preoperative thin-slice contrast-enhanced CT was performed with reconstruction of 3D images (OsiriX™; Pixmeo, Bernex, Switzerland), revealing that two arteries arising from the aorta supplied the left moiety of the HSK and one artery originating from the common iliac artery supplied the isthmus (Fig. 2). We performed RAPN via the transperitoneal approach (Fig. 3), while referring to the reconstructed 3D images on the robotic console. This allowed us to easily achieve selective clamping of the vessel that was thought to supply the posterior renal mass. Because of the tumor location and poor mobility of the left moiety of the HSK, extensive dissection was required to mobilize the left moiety and allow it to be retracted medially. After the posterior surface of the kidney could be visualized, the mass was resected in standard fashion. The console time was 295 min, WIT was 13 min, and estimated blood loss was 100 mL. The patient was discharged without any complications on postoperative day 7. The final pathologic diagnosis of the resected specimen was clear cell RCC pT1a (Fuhrman Grade 2) with negative surgical margins. Local recurrence or metastasis was not detected by follow-up CT at 6 months after surgery. There was no hydronephrosis and renal function was stable, with an estimated glomerular filtration rate (mL/min/1.73 m^2) of 64.1 before surgery and 68.8 at 6 months postoperatively.

Discussion

Several anatomical features of HSK make laparoscopic partial nephrectomy challenging, including variability of the blood supply, limited mobilization of the fused kidney, and abnormal anatomy of the kidneys and adjacent structures. In fact, performance of laparoscopic partial nephrectomy for a renal mass has only been reported in seven patients with HSK.[7–9] The tumors ranged from 2 to 6.9 cm in diameter, WIT was 11–31 min, and estimated blood loss was 70–490 mL. Major complications were not reported in these patients. To date, robot-assisted partial or heminephrectomy for renal tumors has only been reported in three patients with fusion anomalies of the kidney,[6,10,11] including heminephrectomy in two patients[10,11] and partial nephrectomy in one.[6] Thus, our patient is only the second to undergo RAPN for a tumor in a HSK. Raman *et al*. reported the first case of RAPN for oncocytoma arising in a HSK. They resected a 3-cm lower pole tumor (cT1aN0M0), with a WIT of 13 min, and estimated blood loss of 150 mL. Our WIT was similar to theirs, while the estimated blood loss was smaller. The advanced instrumentation of robotic systems seems to be suitable for patients with HSK because greater dexterity allows the surgeon to dissect complex vessels, excise the tumor, and reconstruct the collecting system and cortex despite the difficulty in mobilizing the fused kidney.

Variable blood supply is one of the anatomical features of HSK. After examining the differences of vascular anatomy between HSKs (n = 83) and normal kidneys (n = 248), Majos *et al*. reported that HSKs had nearly twice as many renal arteries as normal kidneys (4.57 *vs* 2.4 per patient).[12] There were several patterns for the level of origin of the renal arteries, with 60% arising from the normal anatomic location above the IMA and 30% arising between the IMA and aortic bifurcation. In addition, more than 15% of the renal arteries arose from below the aortic bifurcation. Not only the origins of the renal arteries, but also the sites where vessels enter the kidney vary in patients with HSK.[12,13] It was also reported that the diameter of many arteries supplying a HSK exceeds the clinically important threshold of 3 mm.[12] Furthermore, only 5% of patients with HSK or kidneys with crossed fused ectopia had one artery on each side according to Glodny *et al*.[14] These reports suggest the importance of identifying variations in the blood supply of the HSK prior to surgery. In our patient, a vessel arising from the common iliac artery supplied the isthmus of the HSK. Viewing 3D reconstructions of the preoperative CT scans allowed us to better understand the complicated anatomy of the HSK and its blood supply, leading to a shorter WIT and less blood loss. During the procedure, the 3D model could be viewed and rotated freely on the console by the operator. This allowed us to identify the vessels for clamping, while avoiding dissection and clamping

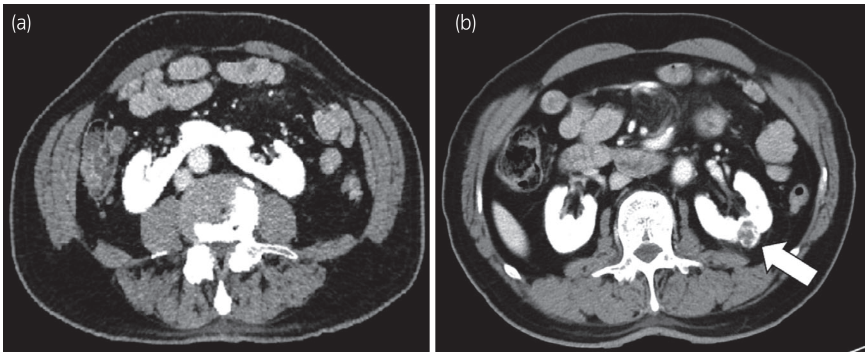

Fig. 1 Contrast-enhanced CT scans of the patient. (a) Axial image demonstrating the fused HSK. (b) A 2-cm enhancing mid-pole mass is located posteriorly in the left moiety of the HSK (arrow).

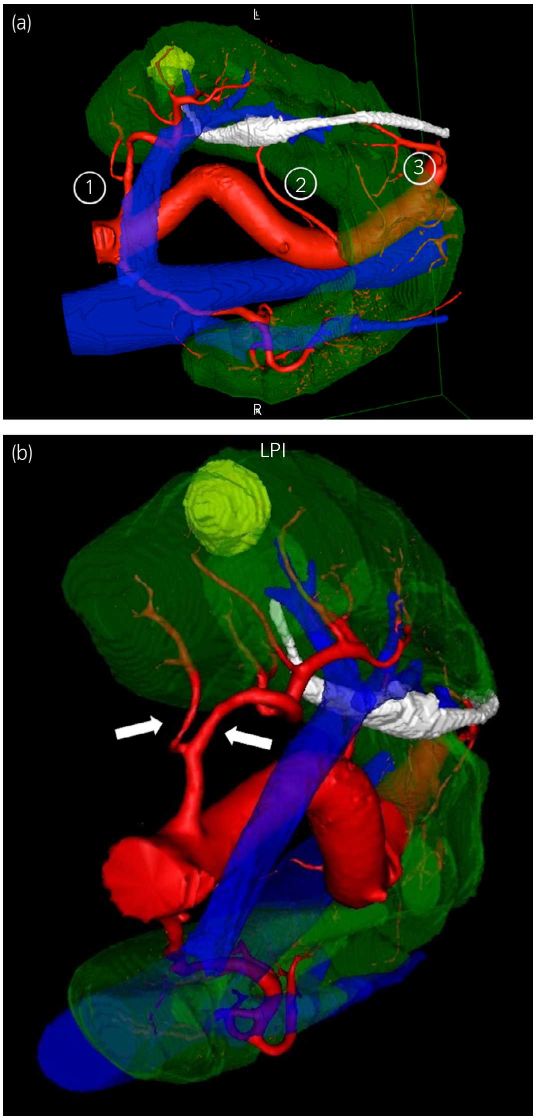

Fig. 2 (a) Preoperative assessment was performed using thin-slice contrast-enhanced CT with reconstruction of 3D images (OsiriX; Pixmeo, Bernex, Switzerland). This revealed two arteries arising from the aorta to supply the left moiety (,) and one artery arising from the common iliac artery to supply the isthmus (). (yellow: renal tumor, green: kidney, red: artery, blue: vein, white: collecting system). (b) Arteries clamped during surgery (white arrows).

of irrelevant vessels. Our experience and previous reports[6,9] both suggest that preoperative 3D simulation is very useful in this setting.

Another factor that makes partial nephrectomy challenging in patients with HSK is the isthmus, which is responsible for poor mobilization of the fused kidney. There was a report that recommended a different approach depending on the location of the renal mass when contemplating laparoscopic surgery.[15] Tsivian *et al*. suggested a transperitoneal approach for anterior, anterolateral, and isthmic lesions, but a retroperitoneal approach for posterior and posterolateral lesions.[16] Among the seven previous reports of laparoscopic partial nephrectomy in HSK patients, four procedures were performed transperitoneally and three were done

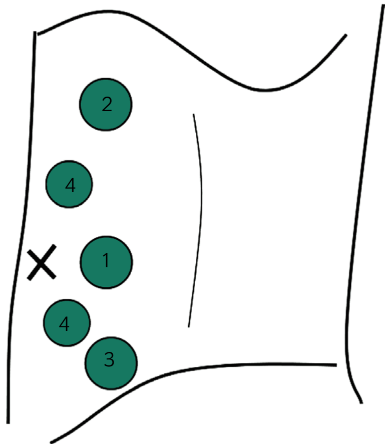

Fig. 3 Ports for robotic partial nephrectomy. ①: 12 mm, camera ②: 8 mm, right hand ③: 8 mm, left hand ④: 12 mm, assistant.

retroperitoneally. None of the seven patients required isthmusectomy. In our patient, we selected the transperitoneal approach because we thought it would be easier to perform operation in wider space although the tumor was located posterolaterally. Although we made preparations to divide the isthmus if we could not mobilize the left moiety of the HSK sufficiently to resect the tumor and suture the tumor bed, we found that retraction of the kidney could be done without transection of the isthmus.

Conclusion

We reported a patient with HSK, in whom a small RCC was successfully resected by RAPN based on 3D reconstructed images of preoperative CT scans. 3D simulation provided us with detailed information about the complex vasculature and collecting system of the HSK. RAPN combined with preoperative CT and 3D image reconstruction seems to be useful for managing renal masses in patients with HSK.

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Conflict of interest

The authors declare no conflict of interest.

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Editorial Comment

Editorial Comment to Robot-assisted laparoscopic partial nephrectomy for horseshoe kidney: A case report

Molina and Gill reported the first case of laparoscopic partial nephrectomy (LPN) for horseshoe kidney (HSK) by the retroperitoneal approach in 2003.[1] The first case of robotic-assisted partial nephrectomy (RAPN) for HSK was reported from the UK in 2017[2] and the second case was reported from Japan.[3] In the present case report, Fujihara *et al*. reported the third successful case of RAPN for HSK.[4] The renal mass, which had a diameter of 2 cm in the lateral mid-pole of the left moiety, was resected using the transperitoneal RAPN procedure.

As discussed by the authors in the present case report, there are three anatomically challenging issues in LPN or RAPN for HSK: (i) high variability of the vasculature; (ii) the presence of the isthmus that could cause reduced mobility of the moiety; and (iii) renal pelvic and ureteral passage in front of the isthmus. Therefore, in the contemporary environment of imaging technology and robotic surgery, it is essential to reconstruct a detailed preoperative three-dimensional (3D) image for each patient to determine whether the trans- or retroperitoneal approach should be used and to determine the necessity of isthmusectomy based on the site of the tumor before and during the surgical treatment of HSK. The 3D reconstruction images have been published in 6 of 10 previous case reports of LPN or RAPN for HSK. However, there have been only three recent case reports (including the present case) in which the contour and positional relationships among the renal parenchyma, tumor, and renal arteries were clearly identified.[2,4,5]

In addition to the previous detailed discussion in the LPN era, there may be slight additional caution in the RAPN era. Tsivian *et al*.[6] suggested that the choice of trans- or retroperitoneal approach depends on tumor location such as anterior, anterolateral, and isthmic locations that are suitable for the transperitoneal approach, whereas posterior and posterolateral tumors are suitable for the retroperitoneal approach; the same recommendations are applicable in the RAPN era. There has been no previous report on isthmusectomy in LPN or RAPN for HSK. Around the vicinity of the isthmus, the transperitoneal approach is suitable for a large operative area[5] and the retroperitoneal approach should be cautious in cases where the robot arm may not extend to the isthmus.

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Conflict of interest

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