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Robot-assisted partial nephrectomy for T1b renal cell carcinoma with complete situs inversus totalis with pre- and intraoperative three-dimensional virtual imaging

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ABSTRACT

Complete Situs Inversus Totalis (SIT) is a rare congenital anomaly characterized by the transposition of organs to a totally inverted position. We present a case of Robot-Assisted Partial Nephrectomy (RAPN) for T1b renal hilum tumor (RENAL score 9) with SIT. All procedures were performed safely using preoperative three-dimensional (3D) virtual image assistance. There were no intraoperative complications, and the patient was discharged uneventfully. Pathological diagnosis confirmed papillary renal cell carcinoma type1. In patients who have renal cancer with SIT, RAPN can be performed safely, and 3D virtual imaging could provide successful surgical outcomes.

1. Introduction

Situs Inversus Totalis (SIT) is a rare congenital anomaly characterized by the transposition of organs to an inverted position. In SIT, it is more difficult to recognize the anatomical landmark in unusual localization, such as the liver, spleen, gonadal vein, and IVC. Here, we present a case of Robot-Assisted Partial Nephrectomy (RAPN) for T1b renal hilum tumor (RENAL score 9) with SIT. The surgical procedures were performed safely, with the assistance of 3D virtual imaging. Imaging assistance facilitated the surgeon to identify the mirrored organs, which was critical for avoiding damage during the surgery.

2. Case presentation

A 59-year-old Japanese male patient was referred to our hospital for incidental detection of left renal hilum tumor by the ultrasound imaging performed for a medical checkup. His previous medical history diagnosed him as complete Situs inversus totalis (SIT). The further contrast-enhanced CT examination revealed the 46 × 43 mm predominantly exophytic renal mass located at the left renal hilum kidney (RENAL score 9). The complete SIT was confirmed by chest X-ray and CT (Fig. 1a and b). No metastasis was suspected, and he was diagnosed cT1b, N0, M0 renal cell carcinoma.

His serum creatinine level was 1.08 and eGFR 55.3 ml/min/1.73 m^2 respectively, and classified as G3a in CKD classification. CT scanning was performed by 64-row CT with consists of an early angiographic phase and delayed phases, and a urinary phase to obtain detailed 3D evaluation with the segmentation of anatomical structures by the imaging software. In the segmentation process, the tumor, the renal parenchyma, renal artery, veins, urinary tract, cysts, body wall, exoskeleton, and liver were extracted individually, then combined into one 3D image (Fig. 2). As shown in Fig. 2, IVC and renal artery were completely mirrored. The computational calculation for the vascular-supplied area suggested one arterial branch for tumor ischemia. To minimize the renal ischemic damage, we planned the selective clamping technique, and to preserve the renal function by reducing normal renal parenchyma loss, we planned the enucleation technique in this case.

RAPN was performed using the da Vinci Xi robotic platform with a four-arm configuration via transperitoneal approach with the assistance of intraoperative three-dimensional 3D virtual imaging for identification of the target organs and structures (Fig. 3). The overall operative time was 215 min, with a warm ischemia time of 12 min with selective clamping. Fig. 2 shows the targeted renal artery in this case. The enucleation technique was adopted for the tumor resection to preserve the normal renal parenchymal volume. In addition to the selective clamping strategy, early unclamping techniques were performed to reduce renal ischemic damage. The estimated blood loss was 40ml, and no intraoperative or postoperative complications were recorded. The

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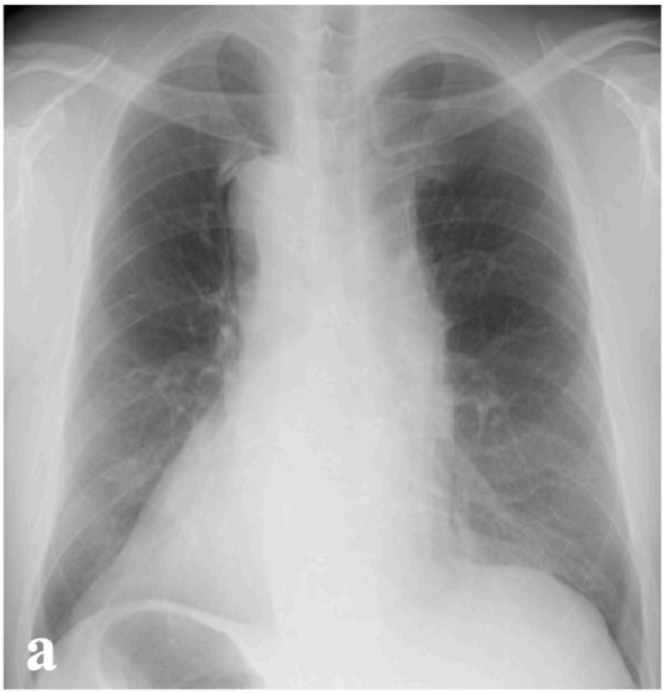

Fig. 1a. Chest X-ray showing dextrocardia.

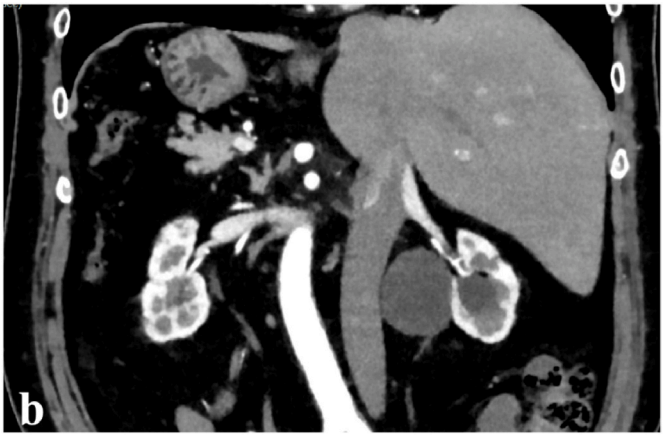

Fig. 1b. CT findings with 46mm exophytic renal mass at the left renal hilum and the complete SIT.

postoperative course was uneventful, with the urinary catheter removed on postoperative day one and the surgical drain on postoperative day 3. The patient was discharged from the hospital on postoperative day 7 in good clinical condition and with an eGFR of 46.3ml/min/1.73 m^2 in one month after the operation. At histopathological analysis, the renal tumor was diagnosed as papillary renal cell carcinoma type 1 (stage pT1b, N0, M0). At a follow-up of 6 months, there was no evidence of local or systemic recurrence.

3. Discussion

For patients with SIT, simply inverting the usual procedure would reduce the risks of misidentifying the surgical anatomy and thus increase safety.

Some case reports describe safety with SIT in the setting of renal cell carcinoma, upper tract urothelial carcinoma, and elective donor nephrectomy as an open procedure.[1] For the laparoscopic approach, few reports were reported. Their results suggested the difficulties and longer

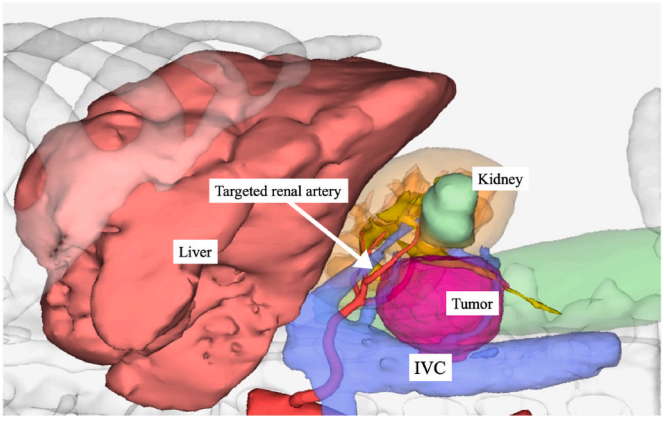

Fig. 2. The 3D segmentation showing the anatomical complexity of renal tumors in SIT.

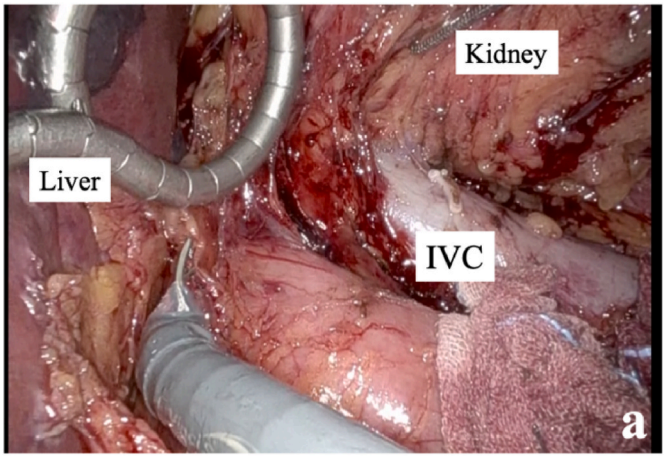

Fig. 3a. Intra operative findings, the mirrored IVC and liver was shown.

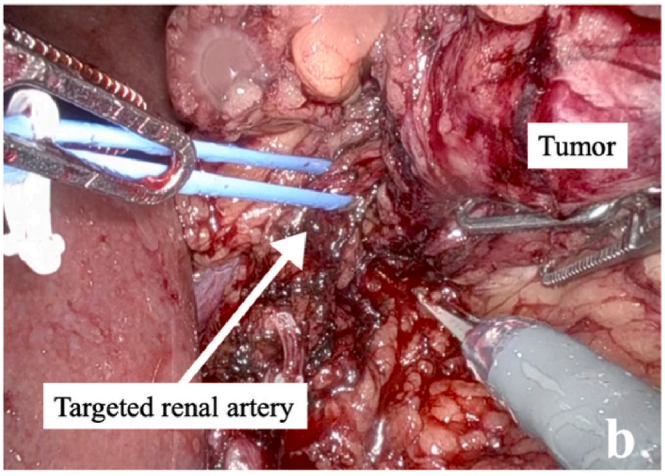

Fig. 3b. Intra operative findings, the exposed renal arterial branch for selective and the renal tumor.

operation time due to disorientation of the limited laparoscopic view of the surgical field.[2] For robotic surgery, Britt et al. reported a successful operation of robotic nephroureterectomy with SIT.[3] In general, for SIT patients, it is essential to confirm the anatomical landmark in unusual localization, such as the liver, spleen, gonadal vein, and IVC. With the

laparoscopic approach, it may become more difficult by the limited operation field of the laparoscopic view. There is no report found with RAPN with SIT. To obtain better RAPN surgical results, the understanding of the internal structure and the positional relationship of the tumor should be detailed. The large, endophytic, central, and hilar tumors were considered challenging compared to small, peripheral, and polar lesions.

In this case, the RENAL score was 9, which meant the anatomically high tumor complexity and unusual condition by the SIT. We performed the virtual 3D surgical simulation and pre-and intraoperative guidance during RAPN.

It allowed us to confirm the unusual landmarks of the patient and assisted us t in focusing on the critical anatomical structures, such as a tumor or targeted arterial branches, in performing select arterial clamping by navigation of the 3D virtual model. In the literature, Makiyama and colleagues reported the case of retroperitoneal nephroureterectomy for a patient with SIT by using a patient-specific simulator before surgery with a successful outcome.[4] Our results also support the benefit of 3D simulation for SIT patients in laparoscopic renal surgery. Since 2015, have performed 3D virtual images based on preoperative CT images for complex RAPN cases.[5] Using the 3D virtual image helps to understand the anatomical complexity of renal tumors in RAPN and also makes it possible to support the surgeon in intraoperative surgical navigation to optimizing by surgical outcomes.

To our knowledge, this is the first report of safely performed RAPN with computational image assistance by the T1b renal cell carcinoma with complete SIT. The virtual 3D surgical simulation can provide the anatomical details in the 3D manner and could assist the surgeon by pre-and intraoperative guidance during RAPN to achieve precision surgery for the patient.

4. Conclusion

We reported the case an underwent uneventful robotic-assisted left partial nephrectomy (RAPN). The surgical management of the renal tumor in patients with complete SIT can be performed safely with the assistance of imaging assistance.

Informed consent and patient details

This study involving human participants was in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration. The investigation committee (IRB) of our hospital approved this study, and informed consent was obtained from the patient.

Author contributions

Shuji Isotan, and Haruka Yazaki,i: Case management, data collection, data analysis, and manuscript writing.

Sou Nakamura, Takeshi Ashizawa, Takeshi Ieda, Toshiyuki China, Haruna Kawano, Fumitaka Shimizu, Masayoshi Nagata, Yuki Nakagawa, Shigeo Horie: manuscript editing, project management.

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Declaration of competing interest

All authors declare that they have no conflict of interest.

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Abbreviations Used

SIT: Situs Inversus Totalis
RAPN: Robot-Assisted Partial Nephrectomy
CT: computed tomography
RENAL score: radius, exophytic/endophytic properties, nearness of tumor to the collecting system or sinus in millimeters, anterior/posterior location relative to polar lines scoring system