Imaging of complications after robotic-assisted nephron-sparing surgery.

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Authors: G. Rech¹, C. Cicero², A. Casarin³, B. De Concilio³, G. Leo², A. Celia³, A. Guarise³, ¹Padova/IT, ²Bassano del Grappa/IT, ³Bassano del Grappa (VI)/IT

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Learning objectives

To show the ability of the imaging techniques, such as ultrasonography (US), contrast-enhanced ultrasonography (CEUS), computed tomography (CT), in evaluating the different postoperative surgical complications after robotic assisted nephron sparing surgery (NSS).
Background

The increased use of imaging as ultrasonography (US), contrast-enhanced ultrasonography (CEUS), computed tomography (CT) and magnetic resonance imaging (MRI), has led to an increase in the diagnosis of smaller, incidentally found renal masses. The 2009 American Urological Association guidelines on management for T1 renal masses identifies nephron sparing surgery (NSS) as the standard of care for T1a and most T1b lesions [1].

Nephron sparing surgery can be performed with an open, laparoscopic or robot-assisted approach, based on the surgeon's expertise and skills. Indications for NSS include T1a-b stage renal cell carcinoma (RCC) and selected masses up to 7 cm, unless contraindicated by unfavourable anatomical location of the tumour or general deterioration of the patient's condition. Absolute indications include tumours in a solitary kidney, impaired renal function and hereditary disorders that predispose to recurrent RCC. Relative contraindications for laparoscopy include prior surgical procedures (due to the presence of intra-abdominal adhesions), cirrhosis and portal hypertension, marked bowel distension (which increases the risk for bowel injury), ongoing sepsis and cardiopulmonary disease [2][3].

The robotic surgical system provides a magnified 3-dimensional view combined with a fully articulating EndoWrist®, which decreases the technical challenge associated with critical portions of minimally invasive NSS, including tumor excision and renal reconstruction [4][5].

During the early postoperative period, vascular complication are the most common complication, with an incidence varying between 0% and 5.26% [6][7].

Other complications are related to a damage of collecting ducts and infections [8][9].

The paper provides an overview of imaging of complications after postoperative robotic NSS and that may be seen at US, CEUS, CT and digital angiography (DSA) imaging.

We report the incidence of complications after NSS in the first 30 days in a single institution.

It is important that radiologists be familiar with the imaging features of postsurgical complications after nephron sparing surgery. Such familiarity allows accurate diagnosis and prompt and appropriate management of any complications.
Findings and procedure details

Study Population

We retrospectively evaluated all patients undergoing robotic NSS from January 2011 and February 2015. All nephrectomies performed at our institution during the specified time period were recorded in our database.

The preoperative selection criteria for nephron-sparing surgery were based on preoperative CT scan Aspects and Dimensions Used for an Anatomical (PADUA) scoring system has been applied to evaluate complications in patients undergoing NSS [10].

Surgical Technique

Robotic laparoscopic surgical technique.

In the majority of patients, NSS is performed via the transperitoneal (TP) route; conversely, posterior and postero-lateral renal tumours are best managed with a retroperitoneal approach [11] [12].

Preoperative ureteral catheterisation may be used, particularly when access to the collecting system is necessary. According to some authors, intraoperative ultrasonography for assessment of renal perfusion, tumour location and borders may prove beneficial and result in a change of procedure in a minority (2.5 %) of patients [13].

After laparoscopic access to the retroperitoneum and opening of Gerota’s fascia, enbloc or selective arterial clamping of the renal hilar vascular pedicle is performed to decrease bleeding and ensure a clear surgical field: the acceptable warm ischaemia time is limited to 30 min or less. Depending on the tumour's size and reconstruction and closure with a combination of absorbable sutures, argon-beam coagulation and haemostatic agents. Finally, after reconstruction is finished, the vascular clamp is released to restore circulation.

Evaluation of complication

For the evaluation of complications after surgery our protocol includes the performance of CEUS before the patient's discharge, to assess the presence of abdominal fluid, bleeding at the time of lumpectomy and the eventual development of pseudoaneurysm.

If appeared symptoms such as hypotension, flank or abdominal pain, gross or persistent haematuria, bleeding from the drainage tube or laboratory abnormalities (particularly
blood loss, leucocytosis and increased C-reactive protein levels) suggest a possible complication, our protocol requires the immediate execution of Multiphase TC acquisition.

Multiphase CT acquisition protocol, including: (1) preliminary unenhanced acquisition to demonstrate the postoperative anatomy and detect hyperattenuating blood and abnormal air/fluid collections; (2) corticomedullary phase and (3) nephrographic-phase images after CM injection to assess the operated kidney structure and perfusion of the operated kidney and to identify CM extravasation indicating active bleeding; (4) excretory phase imaging obtained 8-10 min after CM, which demonstrates the opacified urinary cavities and may detect iodinated urine leaks and urinomas. Postoperative CT studies are reviewed interactively on dedicated workstations and complemented with multiplane constructions as necessary, to better depict postoperative anatomy and relevant findings [14] [15] [16].

In our experience complications were detected in a range period of 30 days. All complications were then carefully graded using the modified Clavien system [17]; grades 1 and 2 complications were classified as minor, and grades 3 through 5 were classified as major.

A total of 89 robotic assisted partial nephrectomies were done between January 2011 and February 2015. Overall 10/89 (8.9%) patients had a complication suspected with US or CEUS and confirmed with CT.

Haemorrhage developed in 4 patients (4.4%). In addition, multidetector CT provides follow-up of conservatively treated lesions.

During partial nephrectomy, the liver or spleen may be inadvertently lacerated or contused by retractors and other surgical instruments used to keep adjacent organs away from the surgical field. Such injuries may be detected with CT and MR imaging.

We have had 1 case of iatrogenic injury to the spleen, detected with CT, which resulted in splenectomy.

Renal artery and intra-parenchymal pseudoaneurysms occur in 3 patients (3.3%) after-NSS procedures, and result from partial or complete injury to an intra-renal artery at the surgical site of resection (SSR).

In our study abscess developed in 2 patients. To diagnose abscess is requires correlation of clinical signs and laboratory data with imaging appearances. At the TC the sign are mostly represented by enlarging intra- or peri-renal hypoattenuating collections with a peripheral, thickened enhancing capsule.

Urine leak developed in 1 patient, diagnosed directly with TC in patient with reported severe pain in the flank. The characteristic appearance of leakage seen on CT relies on identification of CM-opacified urine (80-200 HU) extravasated from the collecting system into the perirenal space, visualised on excretory phase acquisitions.

In one patient occurred dislocation and subsequent repositioning of Double J Catheter.
Robotic assisted partial nephrectomy was converted to open or conventional laparoscopic surgery in 3 patients (3.3%) and to radical nephrectomy in 1 patient (1%). There were no deaths.
Fig. 1: Case 1. A 33 year old man with multicystic clear cell carcinoma (PADUA 10). Preoperative US shows a complex mass of the left kidney with vascularized component.

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Fig. 4: Case 1. Preoperative axial contrast-enhanced CT image of the same patient shows a complex mass with enhancing wall, irregular septa and solid component.

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Fig. 5: Case 1. Preoperative coronal contrast-enhanced CT image of the same patient shows a complex mass with enhancing wall, irregular septa and solid component.

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**Fig. 2:** Case 1 (3 days post NSS). US color doppler module shows echoes with arterial pattern near the area of excision.

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Fig. 3: Case 1 (3 days post NSS). CEUS demonstrates elongated area intensely vascularized near the area of excision.

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**Fig. 6:** Case 1 (3 days post NSS). Axial CT in the arterial-phase (CTA) shows a 1.5 cm enhancing lesion close to a hypoperfuse cortical region in the site of NSS.

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Fig. 7: Case 1 (3 days post NSS). MPR of CTA in the coronal plane confirms a peri-hilar small enhancing lesion.

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Fig. 8: Case 1 (3 days post NSS). MPR in the sagittal plane demonstrate that the enhancing lesion is close to a small interlobar artery.

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**Fig. 9:** Case 1 (3 days post NSS). MIP of CTA in the para-axial plan clearly shows the continuity of the vascular lesion with an interlobar artery and allows the diagnosis of pseudoaneurysm.

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Fig. 10: Case 1 (3 days post NSS). DSA with superselective catheterization shows a pseudoaneurysm at the resection site.

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**Fig. 11:** Case 1 (3 days post NSS). Angiogram obtained after coils embolization shows the exclusion of the previously feeding pseudoaneurysm.

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Fig. 12: Case 2. A 85-year-old man, preoperative contrast-enhanced CT image in the coronal plane demonstrates a solid enhancing mass in the left kidney, which was surgically proved to be a renal cell carcinoma.

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Fig. 13: Case 2 (30 days post NSS). Axial contrast-enhanced CT image obtained during the nephrographic phase demonstrates a collection that extends into the perirenal space composed by opacified urine with presence of gas bubbles.

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**Fig. 14:** Case 2 (30 days post NSS). MIP reconstruction of CT in the excretory phase shows an accumulation of contrast material in the perinephric space which tends to reach the skin surface (fistula). Leakage ceased after placement of a ureteral stent.

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Fig. 15: Case 2 (30 days post NSS). A zoomed MIP of CT in the excretory phase shows an accumulation of contrast material in the perinephric space which tends to reach the skin surface (fistula).

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Fig. 16: Case 3 (3 days post NSS). A 70-year-old man suffering from persistent pain 3 days after left renal tumour resection (papillary carcinoma). Axial contrast-enhanced CT shows a peri-renal hypoattenuating collection with peripheral enhancement and presence of gas bubbles, suggesting infection.

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**Fig. 17:** Case 3 (3 days post NSS). Contrast CT in the coronal plan better depict a peri-renal hypoattenuating collections with peripheral enhancement and presence of gas bubbles suggesting infection.

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Conclusion

US implemented by CEUS is an excellent diagnostic modality to be used in the first instance, in non-critical patients, in evaluating possible complications after NSS.

Perirenal hemorrhage, intrarenal bleeding with pseudoaneurysm formation, arteriocaliceal fistula or urinal leak are serious complication after nephron-sparing surgery, and requiring prompt diagnosis and treatment. In our experience multidetector CT imaging allows detection of all kind of complications [18].

DSA with selective embolization is a safe and efficacious technique for the appropriate management of vascular complication.
Personal information

Giulia Rech MD, Radiology Department University of Padua (PD), Italy
giulia.rech@gmail.com

Calogero Cicero MD, Radiology Department, "San Bassiano" Hospital, Bassano del Grappa (VI), Italy
calogero.cicero@asl.bassano.it

Andrea Casarin MD, Radiology Department, "San Bassiano" Hospital, Bassano del Grappa (VI), Italy
stano.canestrini@asl.bassano.it

Bernardino De Concilio MD, Urology Department, "San Bassiano" Hospital, Bassano del Grappa (VI), Italy
bernardinodeconcilio@hotmail.com

Genesio Leo MD, Pathological Anatomy Department, "San Bassiano" Hospital, Bassano del Grappa (VI), Italy
genesisio.leo@asl.bassano.it

Antonio Celia MD, Urology Department, "San Bassiano" Hospital, Bassano del Grappa (VI), Italy
bernardinodeconcilio@hotmail.com

Alessandro Guarise MD, Radiology Department, "San Bassiano" Hospital, Bassano del Grappa (VI), Italy
alessandro.guarise@asl.bassano.it
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