

Surgery Illustrated – Surgical Atlas

Robotic-assisted partial nephrectomy

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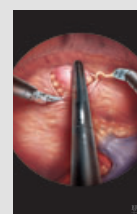
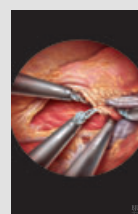
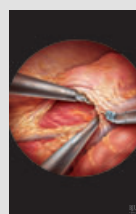
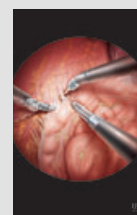
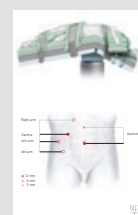
INTRODUCTION

Surgical resection is the standard for treatment for RCC and partial nephrectomy (PN) is the treatment of choice for tumours <4 cm [1]. Laparoscopic PN (LPN) is a viable alternative to traditional open PN, giving good oncological and functional outcomes [2–4]. LPN is a challenging procedure, particularly with intracorporeal suturing under the time constraints of warm ischaemia. The introduction of the da Vinci surgical system (Intuitive Surgical Inc., Sunnyvale, CA, USA) with wristed instruments and magnified, three-dimensional vision, can facilitate the technical challenges of minimally invasive PN. The technique of robotic PN (RPN) is still developing and several institutions have recently reported their results [5–11]. Here we present our technique for RPN using a transperitoneal approach.

PLANNING AND PREPARATION

INDICATIONS AND PATIENT SELECTION

Absolute indications for PN include patients with an anatomical or functional solitary kidney, or evidence of tumour in the contralateral kidney [1]. PN can be performed electively in patients with localized RCC and a normally functioning contralateral kidney. For tumours <4 cm, recurrence rates are similar to those for radical nephrectomy [1] and thus PN is generally performed. However, PN can also be done in selected patients with tumours >4 cm [12]. RPN has been described for patients with complex renal tumours (hilar, endophytic or multiple) [9], but these are advanced procedures and should be done in selected patients by a surgeon with



considerable experience. If the patient does not meet these criteria, a radical nephrectomy is recommended. Relative contraindications to a minimally invasive approach include extensive previous abdominal surgery and patients with renal insufficiency who cannot tolerate warm ischaemia.

PATIENT-SPECIFIC PREPARATION

All patients being considered for RPN undergo a metastatic evaluation, including imaging with abdominal CT or MRI, and an anteroposterior and lateral chest X-ray. Additional imaging such as a chest CT, head CT and bone scan are ordered based on clinical signs and symptoms of metastasis. In addition, all patients have a full blood evaluation, including electrolytes, blood urea nitrogen, creatinine, complete blood count, coagulation studies, and liver function tests.

All patients are instructed to stop any anticoagulants at least 5 days before surgery. Patients can be given a bowel preparation,

such as magnesium citrate, the day before surgery. They are also instructed not to eat or drink anything after midnight on the night before surgery. A first-generation cephalosporin is routinely given ≈ 30 min before incision.

The surgical team includes one operating console surgeon, one bedside assistant and a surgical technician. The operating surgeon can scrub initially to assist in patient preparation and port placement, and then breaks scrub before sitting at the robotic console. The bedside team remains scrubbed throughout the case and assists the console surgeon during the procedure.

SPECIFIC EQUIPMENT/MATERIALS

Instruments used by the console surgeon are:

Dissection and excision;

- right hand – hot shears monopolar curved scissors or monopolar hook;

- left hand – maryland bipolar forceps, fenestrated bipolar forceps, or prograsp forceps;

Renal reconstruction;

- two large needle drivers (or one needle driver in the right hand and forceps in the left hand, at the discretion of the surgeon);

Fourth robotic arm instruments (optional);

- dual blade retractor or double fenestrated retractor;

Instruments used by the bedside assistant;

- 5 mm laparoscopic grasper;
- 5 mm laparoscopic needle driver;
- 5 mm laparoscopic scissors;
- Laparoscopic bulldog clamp applier;
- 5 mm and 10 mm hem-o-lock clip applier;
- Long suction tip and irrigator;
- 10 mm specimen extraction bag;
- Jackson-Pratt drain with suction bulb.

Figure 1**OPERATING ROOM SYSTEM**

We use the da Vinci S Surgical system for RPN; the operative system, including the position of the robot, console surgeon, bedside assistant, surgical technician and monitors, is illustrated in Figure 1.

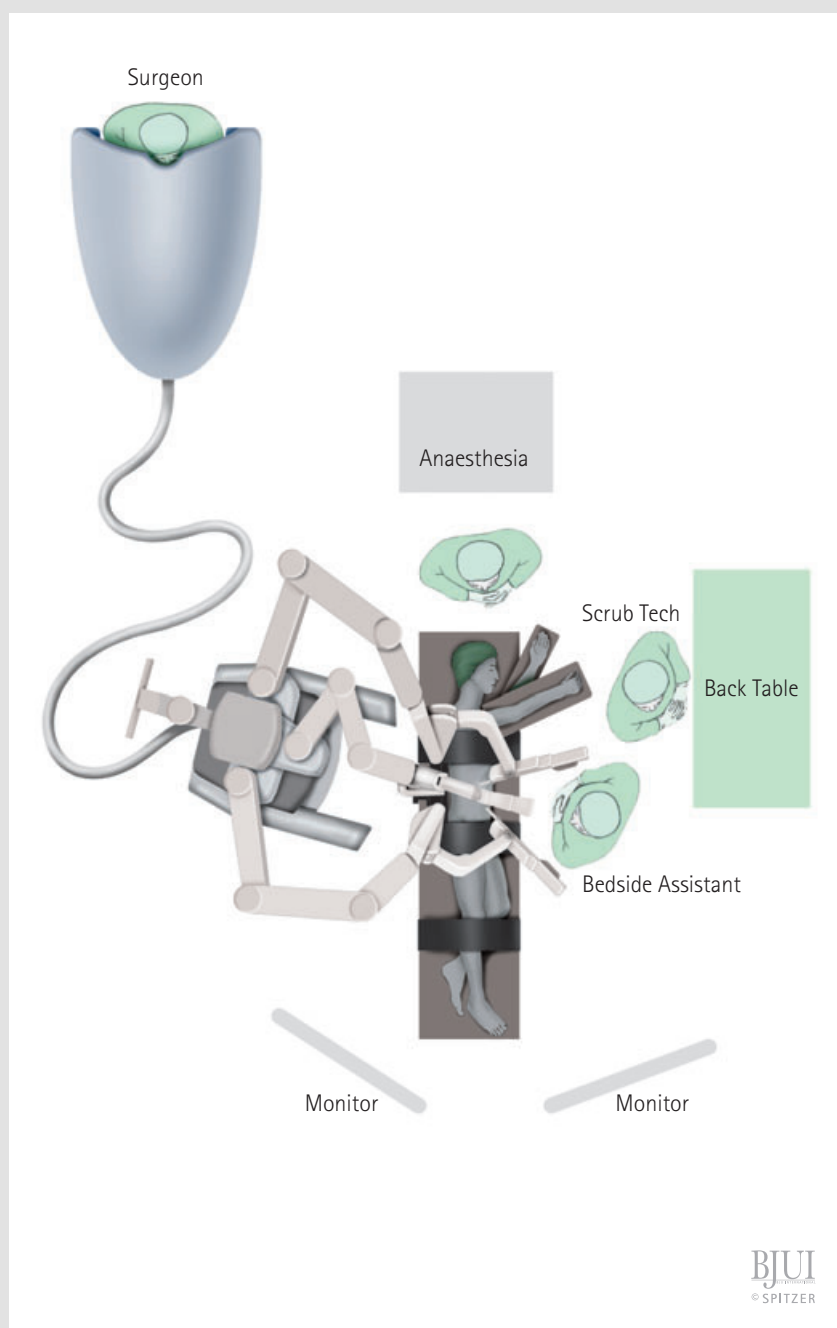


Figure 2

PATIENT POSITIONING

General endotracheal anaesthesia is used for this procedure. A Foley catheter is placed before positioning the patient. The patient is placed in the flank position. Mild table flexion can be used to increase the space for ports, with the kidney placed in the centre of the table break. All pressure points are carefully padded and the patient is secured to the operating table with strong tape. The lower leg is flexed and the upper leg is straightened. One or two pillows are placed between the legs. A kidney rest is not routinely used.

Step 1: Trocar placement. A 12-mm port for the robotic camera can be placed laterally using a 0° or 30° up-angled endoscope [10,13] or medially using a 0° or 30° down-angled endoscope [9]. Two 8-mm robotic ports are placed under vision at least 5–6 cm on each side of the camera. With a medial camera position these three ports are triangulated towards the renal hilum. With a lateral camera position, the ports are more in a line that is perpendicular to the line drawn from the camera port to the hilum. A port for the fourth robotic arm can be placed ≈10 cm medially to the most caudal robotic instrument port. A 12-mm assistant port is placed near the umbilicus or lateral to the rectus in obese patients. An optional 5-mm assistant port can be placed if necessary. For right sided cases, a 5-mm subxiphoid port can be placed for liver retraction. The robot is docked posteriorly at ≈20° towards the head of the patient.

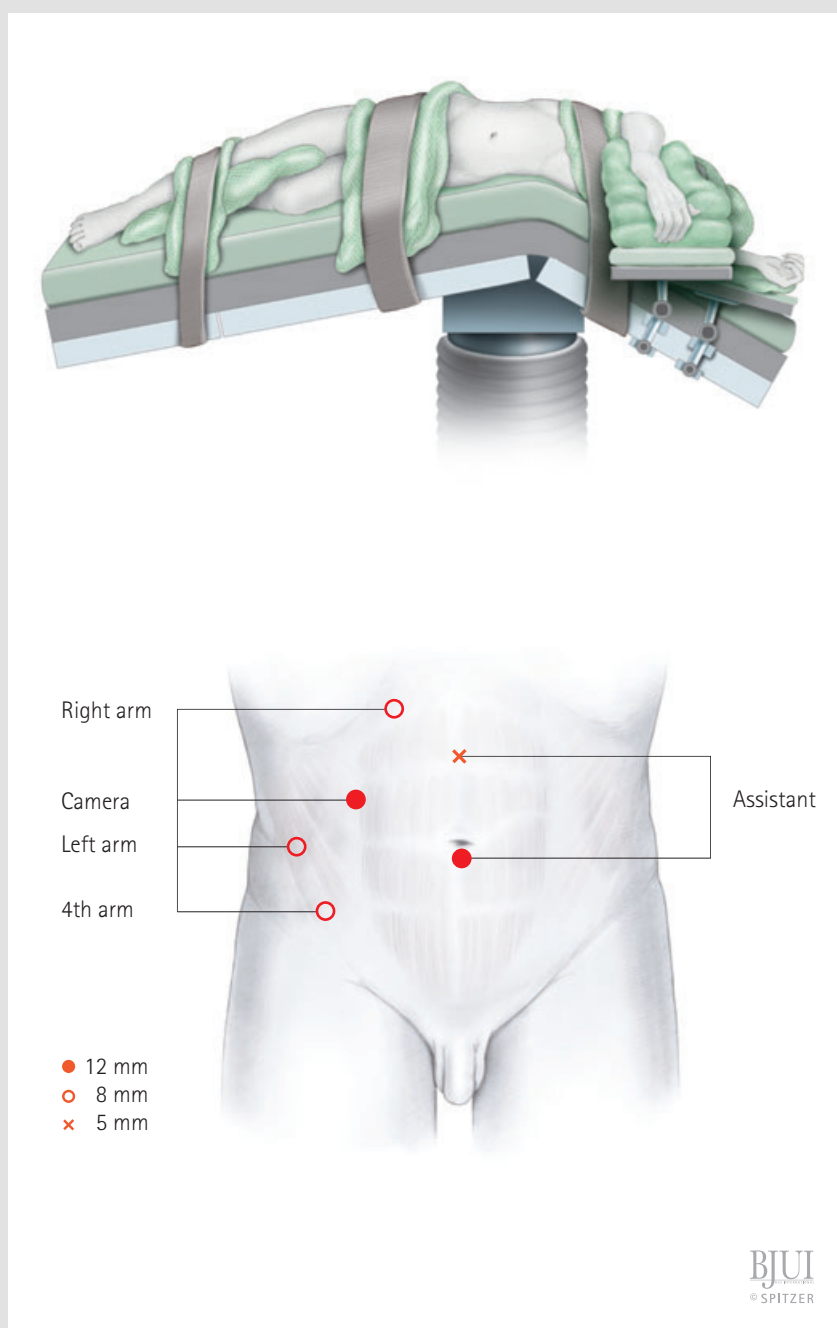


Figure 3**MEDIAL MOBILIZATION OF THE BOWEL**

The colon is mobilized medially to expose the kidney. The superficial layer of peritoneum lateral to the colon is incised along the white line of Toldt. The colon is reflected medially using sharp and blunt dissection. The assistant provides medial counter-traction on the colon while developing the relatively avascular plane between the posterior mesocolon and anterior Gerota's fascia. This dissection is continued along the upper pole of the kidney to mobilize the spleen or liver. Although 'hybrid' approaches using laparoscopy for bowel mobilization have been described, we use robotic assistance from the beginning of bowel mobilization, and have minimal problems of sufficient reach with the da Vinci S system. If the robotic working instruments are attached to cautery, care must be taken to avoid thermal injury to the bowel.

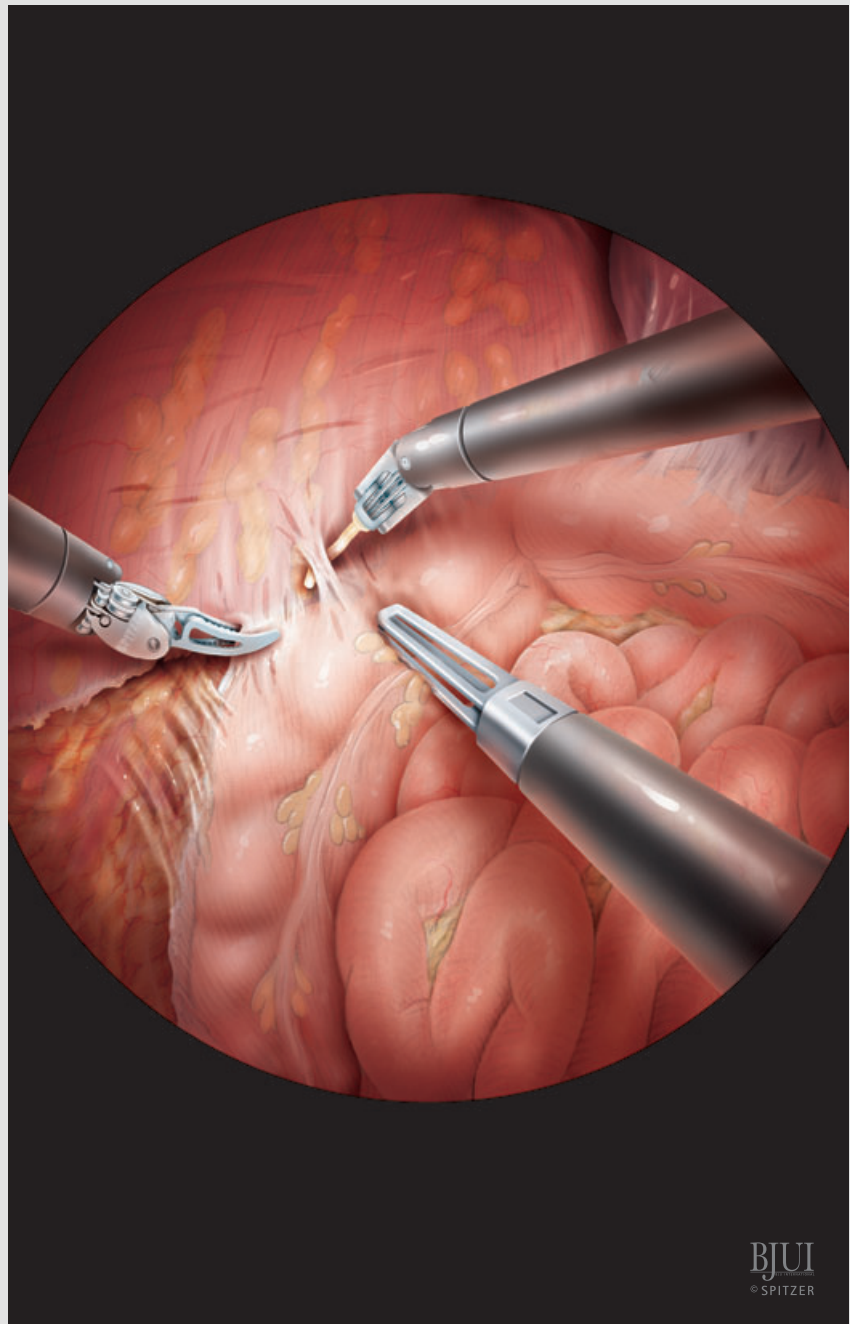
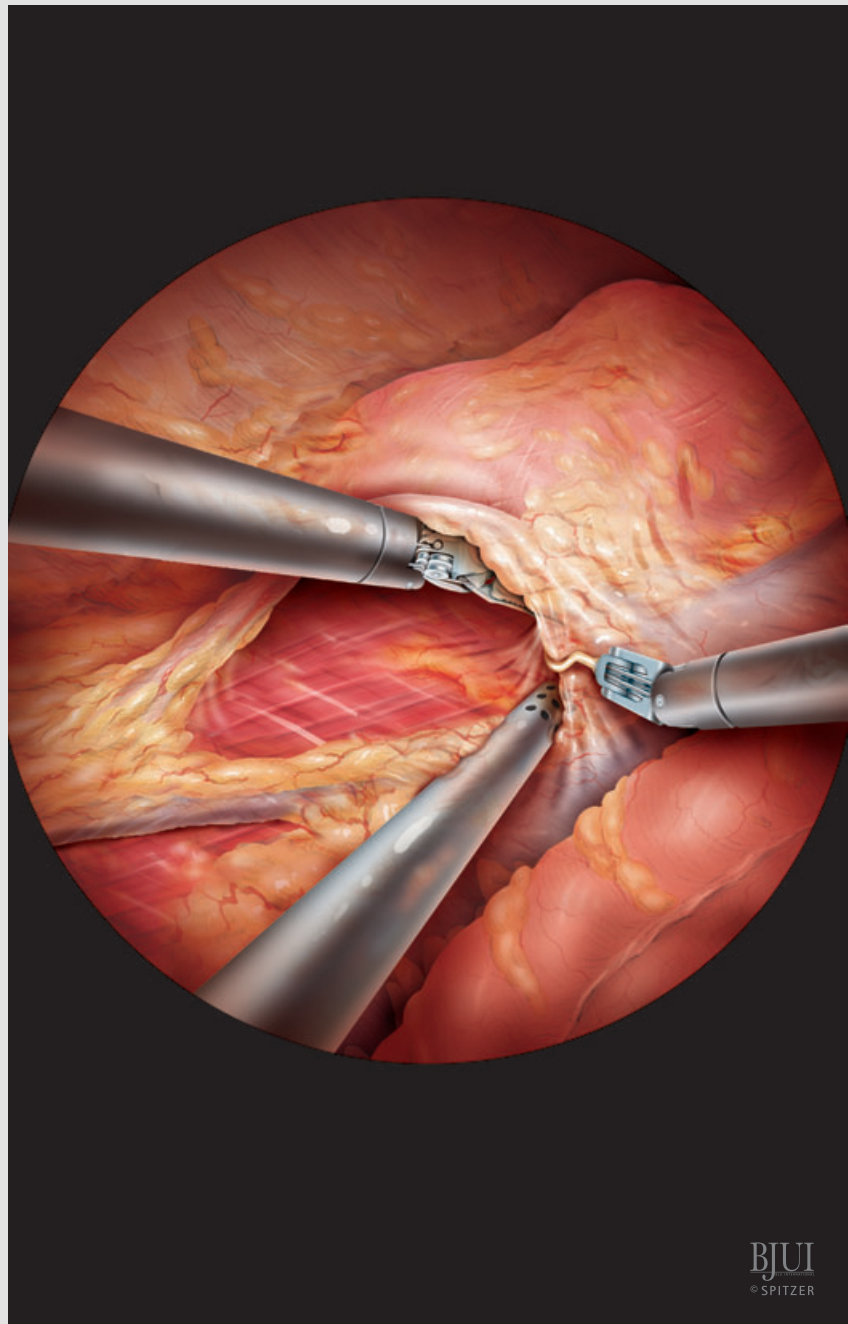
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Figure 4**IDENTIFY ANATOMICAL LANDMARKS**

Continued medial reflection of the bowel and upward retraction helps to expose the ureter and gonadal vein. These structures are retracted anteriorly to expose the underlying psoas muscle. Dissection then turns toward the renal hilum.



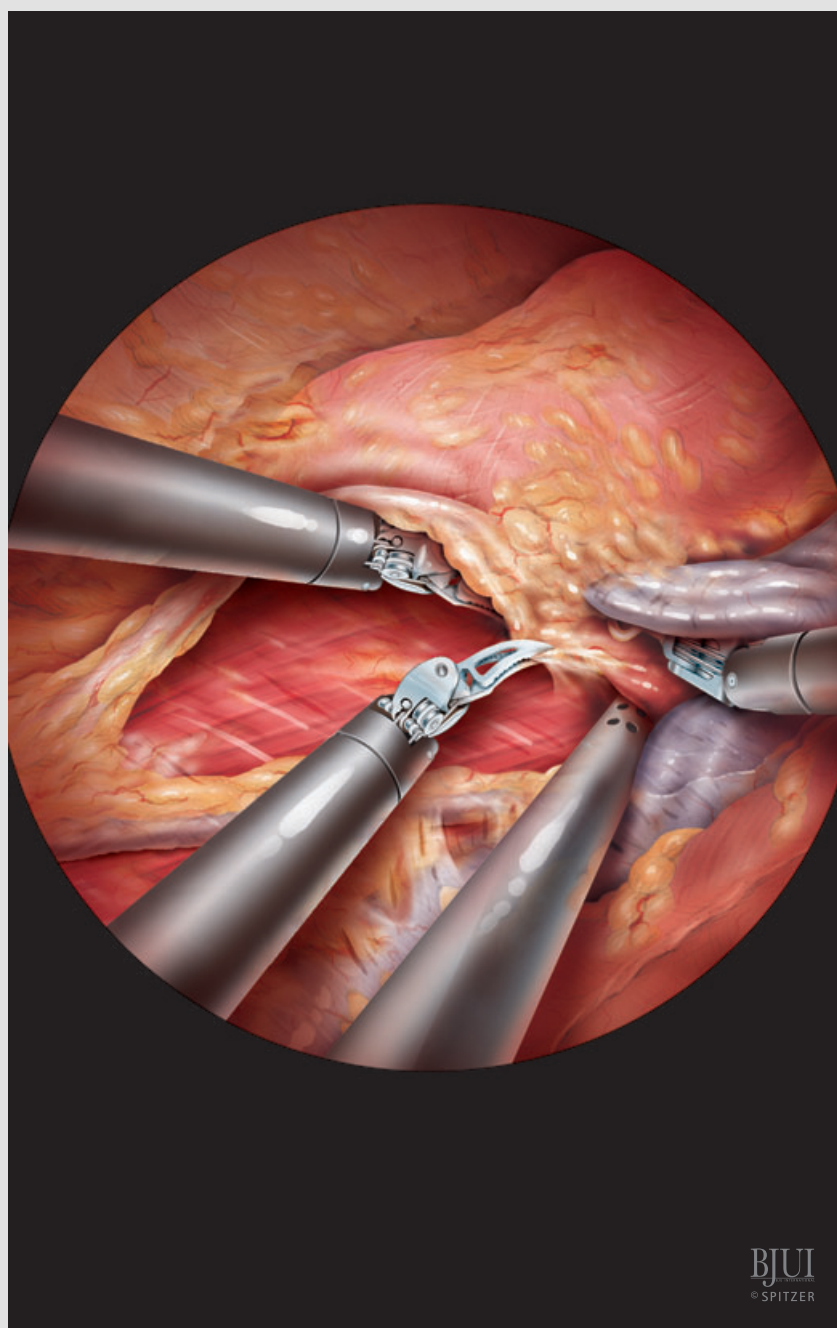
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Figure 5

HILAR DISSECTION

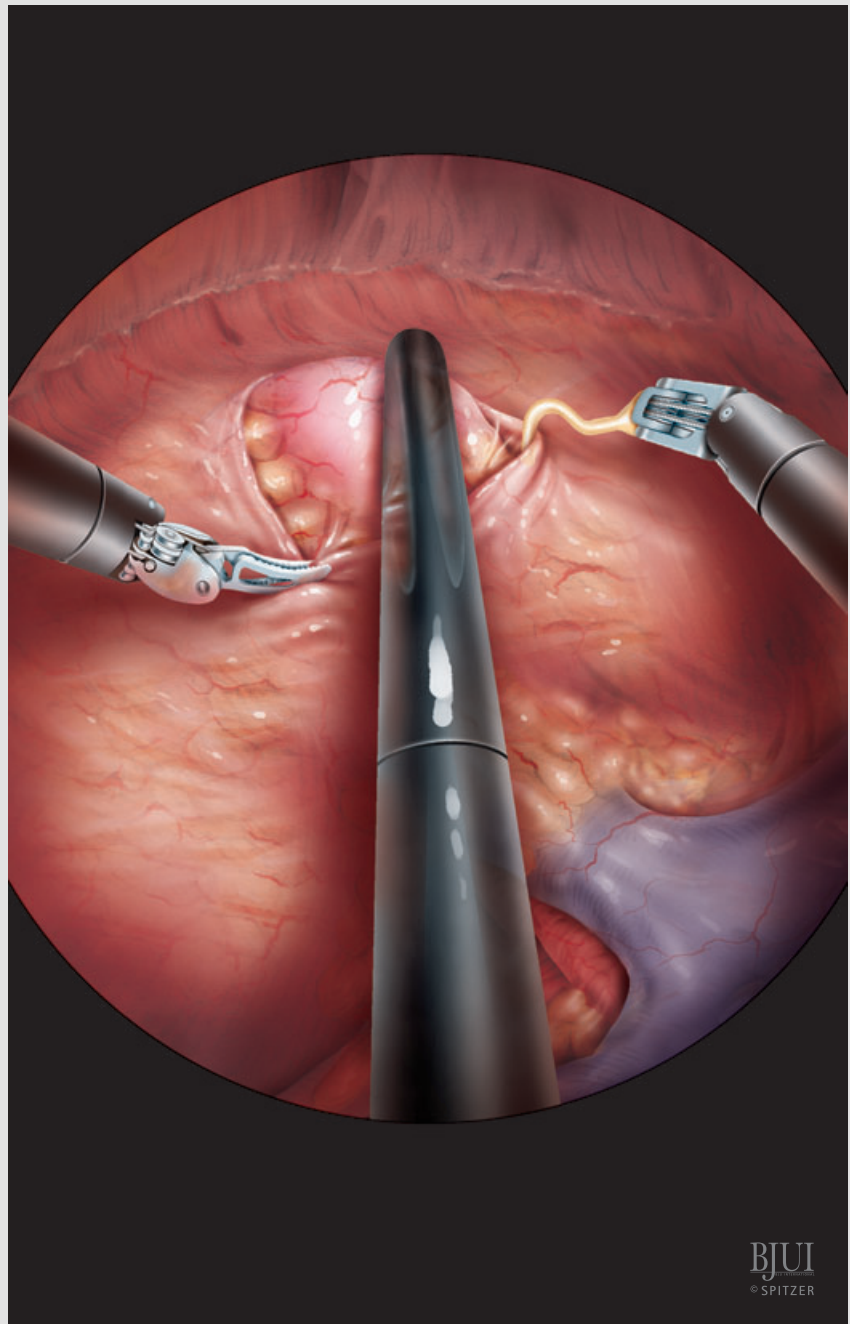
The hilum is identified by tracing the gonadal vein in a cranial direction. On the right, the gonadal is traced to the vena cava, and then followed to the renal vein. On the left, the gonadal is traced to its insertion in the renal vein. Once the renal vein is identified, the renal artery is identified and dissected. Visualization of arterial pulsations can aid in identifying the location of the renal artery. The renal vein is often identified first, as it is anterior to the renal artery. Small venous branches and lymphatic vessels are divided as necessary to expose hilar vessels. To assist in hilar dissection, the fourth robotic arm instrument can be used to lift the kidney anteriorly by placing it under the ureter. This places the renal hilum under tension, allowing two-handed dissection of hilar structures.

Different instruments offer different relative advantages during hilar dissection. In the left hand, the broad and smooth tips of the Prograsp or fenestrated bipolar instruments can be used to spread along renal vessels for atraumatic exposure. However, the fine sharp tips of the Maryland bipolar forceps can be used for precise cauterization of small lymphatics and vessels. In the right hand, the monopolar hook instrument is useful for blunt dissection of hilar vessels. However, the monopolar scissors can be used as a right-handed instrument from the beginning of the case to reduce cost, as it is used later for tumour resection.

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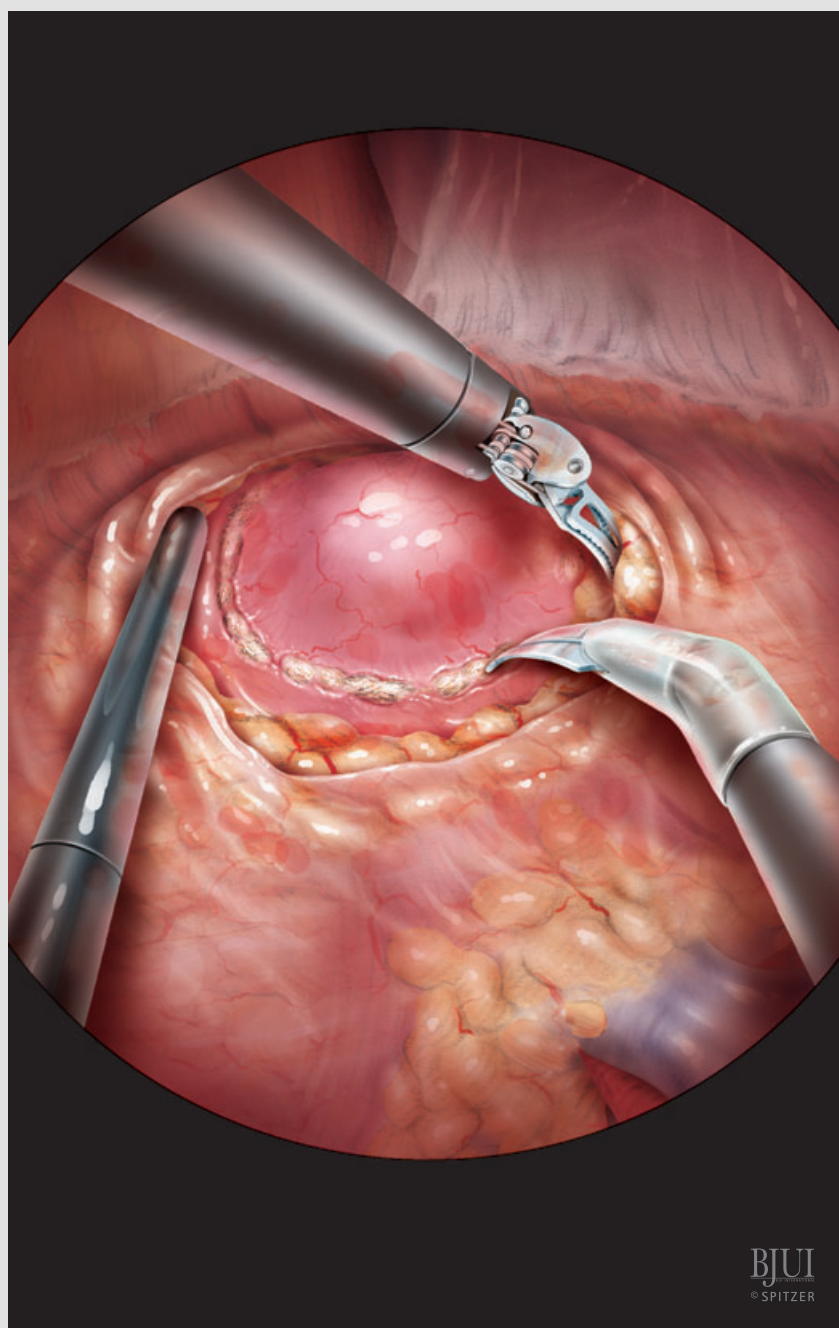
Figures 6 and 7**TUMOUR IDENTIFICATION**

Flexible laparoscopic ultrasonography is introduced through the 12-mm assistant port and used to locate the renal tumour and delineate margins of resection. Intraoperative ultrasonograms and preoperative CT images can be displayed on the console screen as a picture-on-picture display using the TilePro feature of the da Vinci S system, by tapping the camera pedal to turn the images on or off. Gerota's fascia is opened to expose the tumour and sufficient surrounding normal parenchyma to allow for placing sutures during later capsular reconstruction. Intraoperative ultrasonography is used to demarcate tumour margins. Margins of resection are marked by scoring the renal capsule with the monopolar scissors. The kidney is positioned for optimal access to the tumour during excision and renal reconstruction.



PATEL *ET AL.*

Figure 7



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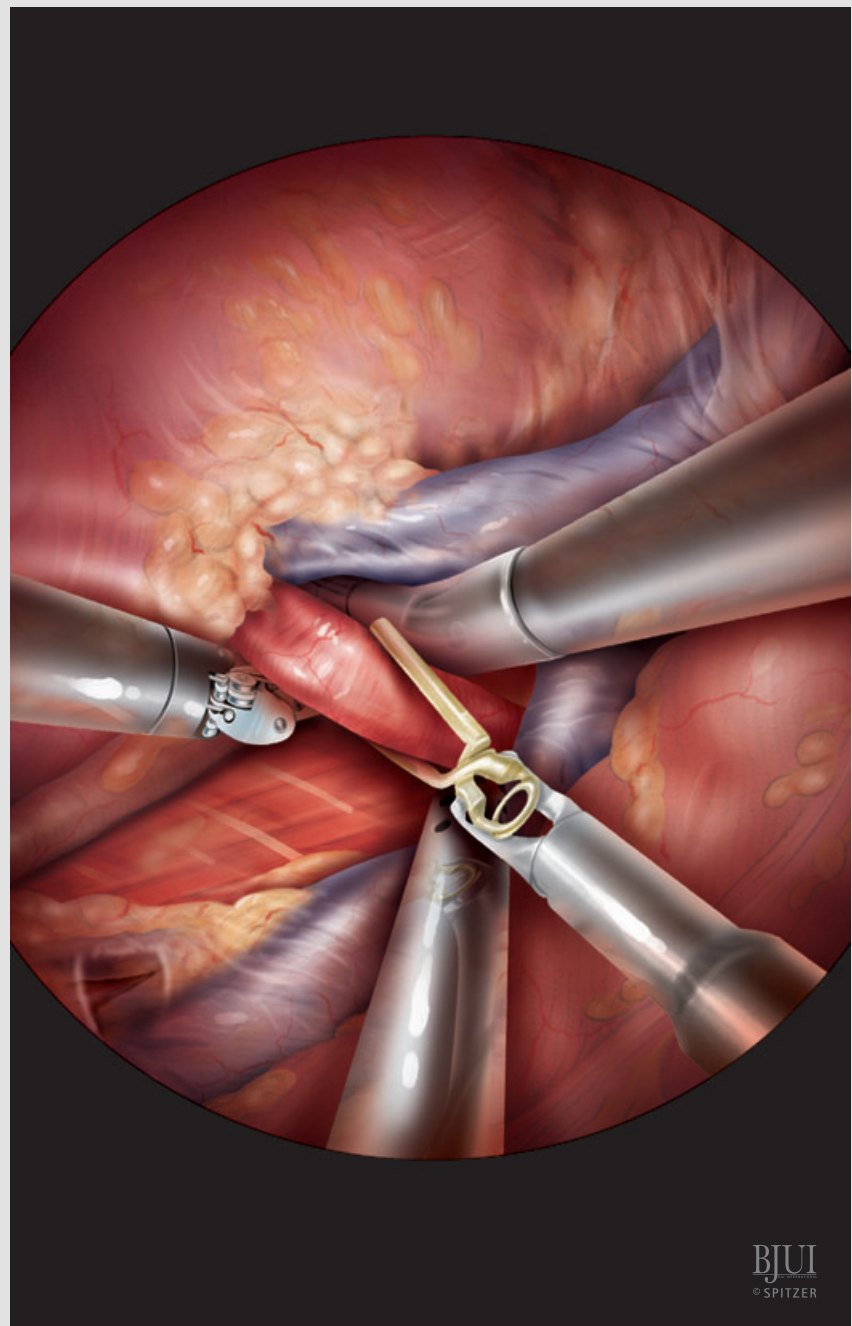
Figure 8**HILAR CLAMPING**

Before clamping, ensure that all sutures and instruments are available for resection and renal reconstruction, and that there is adequate CO₂ for insufflation during the period of warm ischaemia. The patient is given 12.5 g of mannitol before clamping for osmotic diuresis.

Hilar clamping is done by the assistant through the 12-mm port using either laparoscopic bulldog clamps or en-bloc using a Satinsky clamp. The renal artery is clamped first, followed by the renal vein. For small or exophytic tumours, the renal artery alone can be clamped. For large, hilar or endophytic tumours we recommend clamping both the renal artery and renal vein for improved visualization.

Use of the Satinsky clamp for en-bloc occlusion of the renal hilum requires a dedicated port, therefore the assistant must be able to perform all tasks through a single port, or an additional port must be placed. Care must be taken to avoid movement of the clamp or collision with any of the robotic arms, as this could cause injury to renal vessels.

For small exophytic tumours, excision and reconstruction can be attempted without hilar clamping, but we recommend pre-dissecting the renal hilum to allow for vascular control if needed.



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Figure 9

TUMOUR EXCISION

Cold excision with monopolar scissors is used along the demarcated plane to excise the tumour with a small margin of normal renal parenchyma. Care must be taken to avoid trauma to the tumour with the left robotic instrument while providing counter traction. The blunt tipped Prograsp or fenestrated bipolar instruments can be useful in this step. A ureteric catheter can be placed before surgery for endophytic or hilar tumours, to help identify collecting system entry, but this is not routinely used at our institution as the magnification provided by the robotic camera is sufficient to identify entry into the collecting system. During excision, the assistant uses a suction tip to clear any blood from the surgical field, as well as to apply counter-traction on the renal parenchyma to help delineate the plane of resection. Once the tumour is excised, it is placed aside for later retrieval.

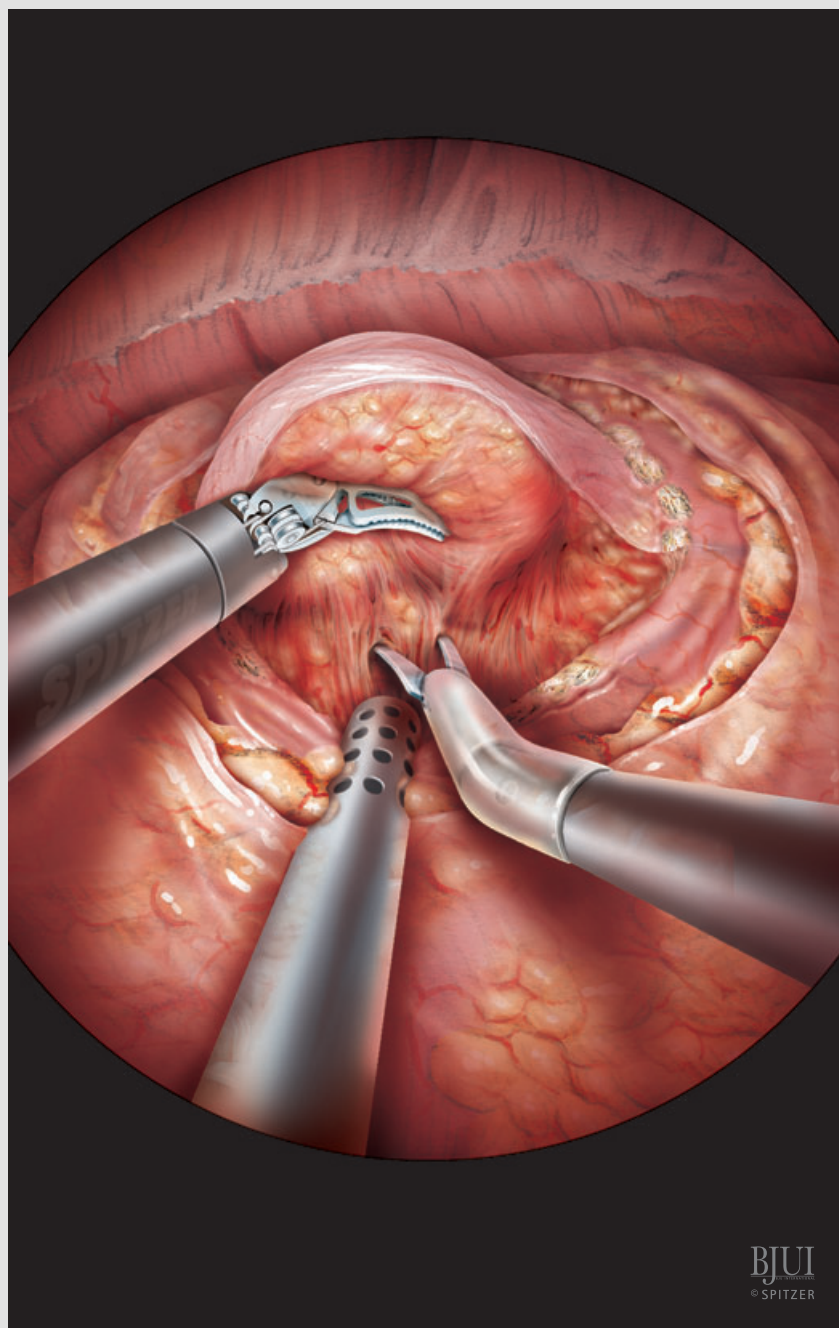
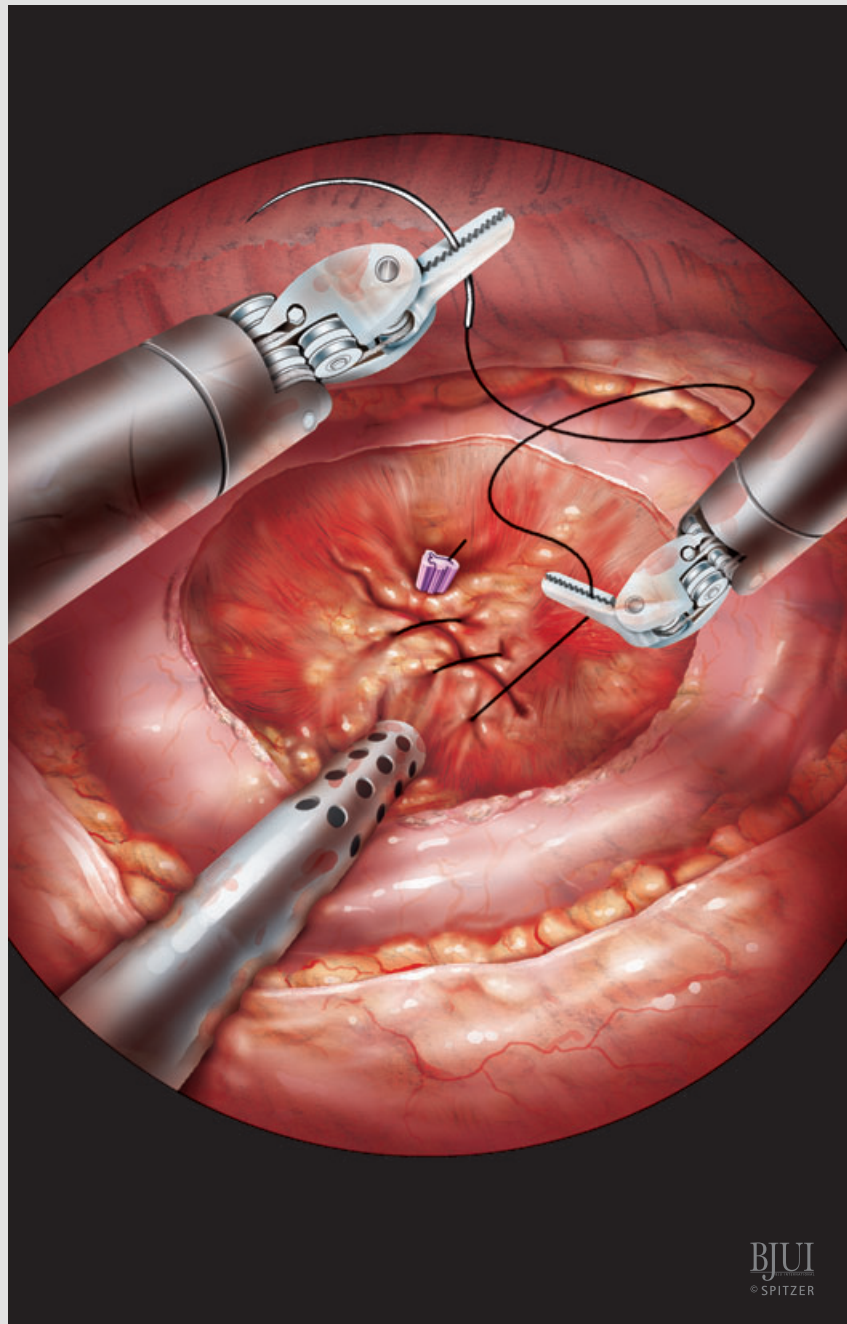
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Figure 10**RENAL RECONSTRUCTION**

The robotic instruments are exchanged for robotic needle drivers. The Prograsp or fenestrated bipolar instruments can be kept in the left hand and used as a needle driver, as per the surgeon's preference.

Inner layer closure: A 3-0 or 4-0 polyglactin suture on a RB-1 or SH needle is used to achieve haemostasis and repair any entry into the collecting system. The end of the suture is prepared with a pre-placed Lapra-Ty (Ethicon, J&J, Piscataway, NJ, USA) to avoid knot tying that would unnecessarily prolong the warm ischaemia time. Another Lapra-Ty is placed by the assistant to secure the stitch when the suturing is completed. Additional sutures can be placed to close the inner layer as needed.

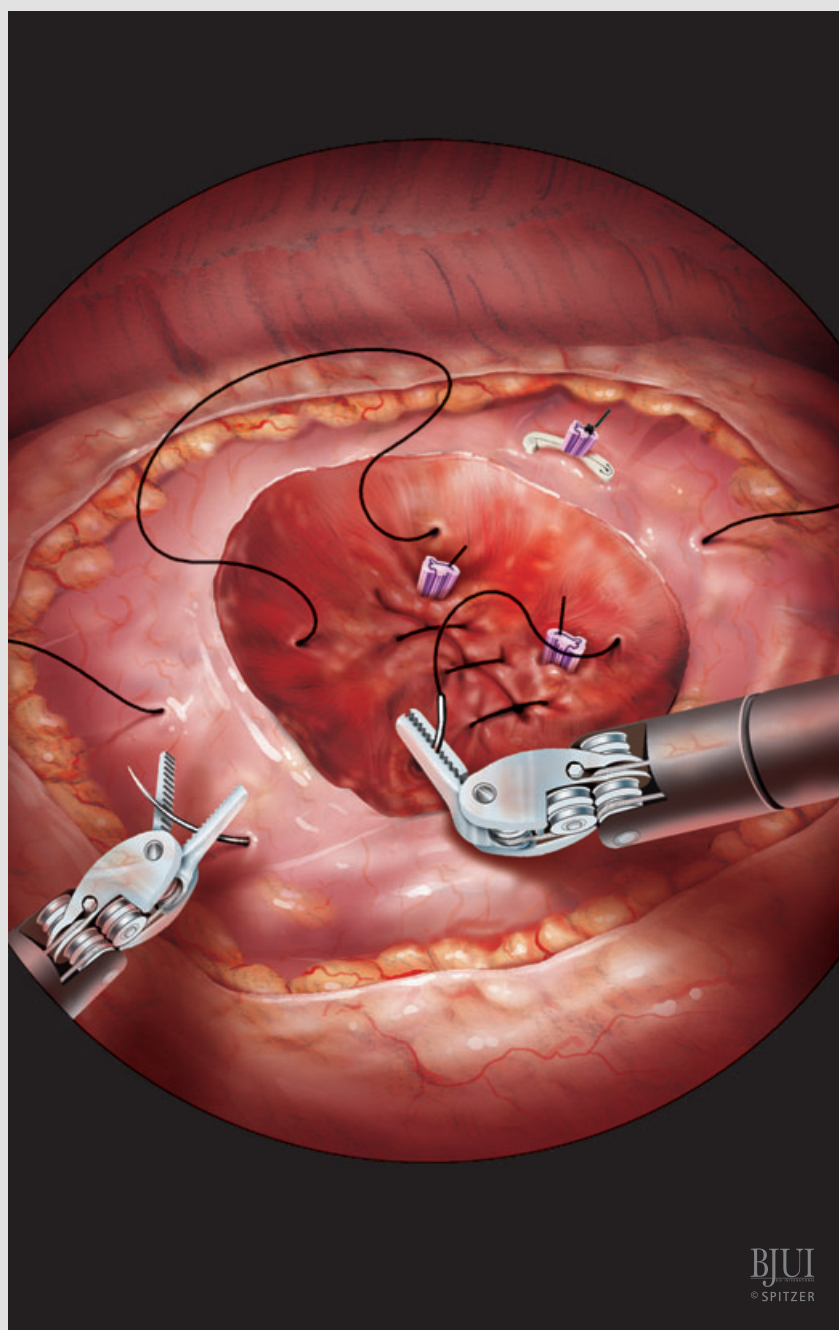
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Figures 11 and 12

CAPSULE RECONSTRUCTION

0-Polyglactin sutures on a CT-1 needle, cut to a length of ≈ 12 cm, are prepared with a haemostatic clip (Hem-o-Lok™ Weck Closure Systems, Research Triangle Park, NC, USA) secured on the outer end with a Lapra-Ty and knot. Interrupted sutures are placed to help re-approximate the capsular edges. Large bites of capsule are taken to ensure that the suture does not tear through. Surgicel™ bolsters (Ethicon) and haemostatic agents, e.g. Floseal (Baxter, Deerfield, IL, USA) can be applied as per the surgeon's preference. The sutures are secured on the other side of the capsule with large Hem-o-Lok clips, placed by the assistant and tightened down by the console surgeon to re-approximate capsular edges under tension [14]. Hem-o-Lok clips are used for the interrupted sutures to spread the force of the suture over a larger surface area, thus allowing stitches to be cinched tighter for a closer re-approximation of the edges, and better haemostasis. After hilar unclamping, Lapra-Ty clips are placed by the assistant on the capsular stitches next to the Hem-o-Lok clips to secure them. The sutures are cut and the needles are removed.

Step 9: Removal of hilar clamps: After reconstructing the renal defect, the hilar clamps are removed. If bulldog clamps are used, the venous clamp is removed first, followed by 'flashing' of the arterial clamp to confirm haemostasis. Haemostasis can also be tested by reducing the pneumoperitoneum pressure. If oozing continues, pressure can be applied to the resection site with a laparoscopic sponge. We give a second dose of mannitol after unclamping the renal hilum.



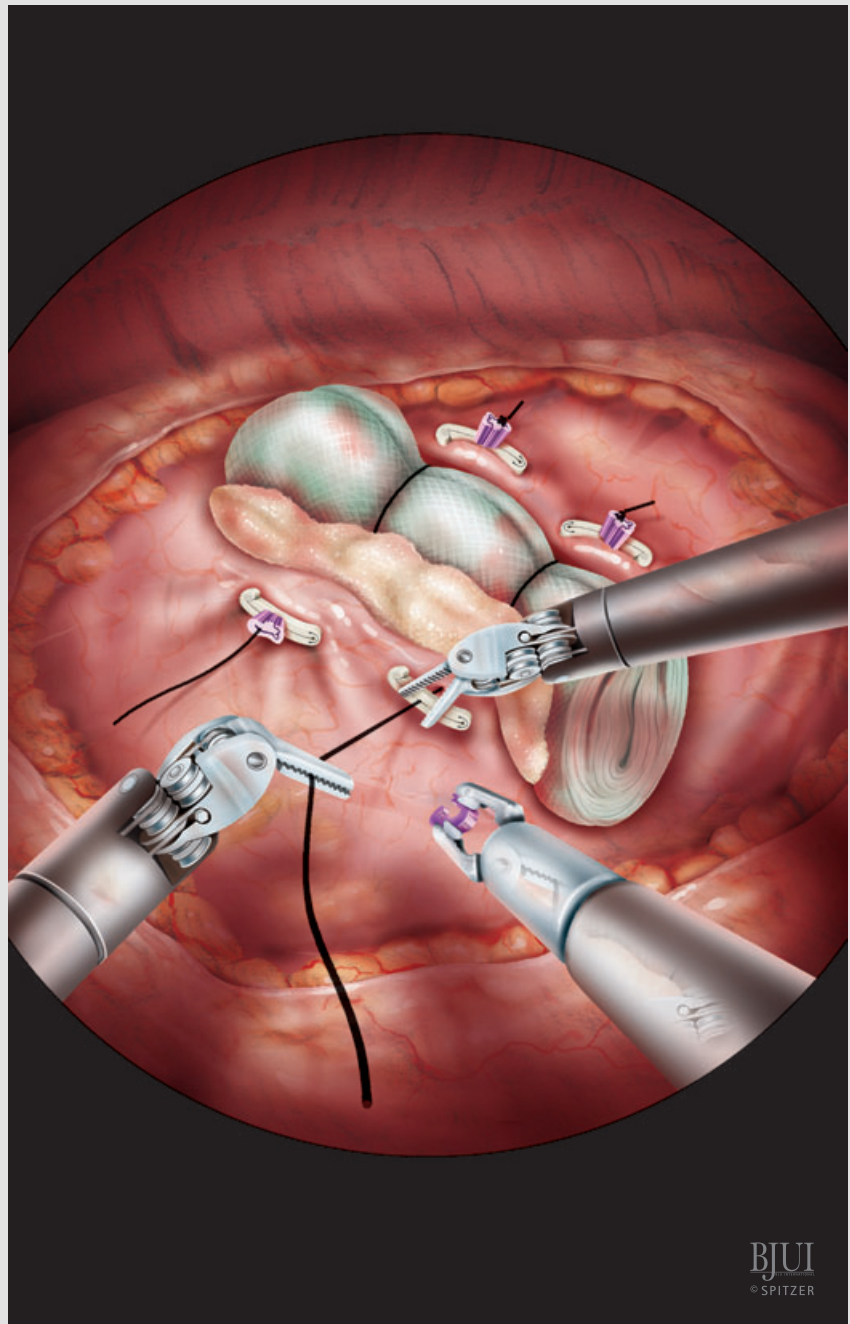
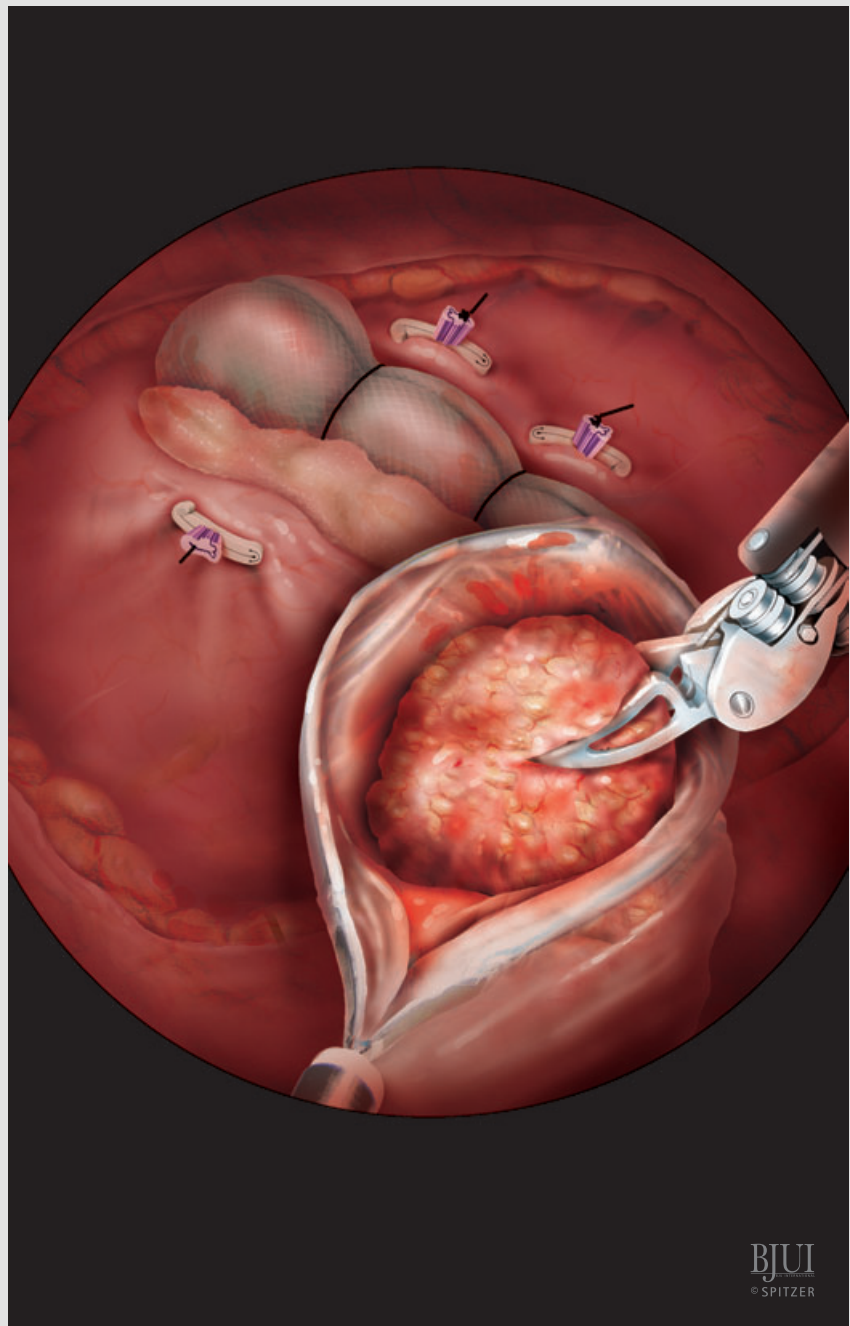


Figure 13**SPECIMEN RETRIEVAL AND CLOSURE**

The specimen is retrieved and placed into an extraction bag inserted through the primary assistant port. A Jackson-Pratt drain can be placed through the most lateral robotic arm port site. The 12-mm assistant-port incision is extended to remove the tumour specimen. The fascia of the incision is closed with interrupted 0-braided polyester sutures. The skin is closed with 4-0 braided polyglactin, subcuticular sutures, and sterile strips.

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POSTOPERATIVE CARE

A complete blood count and electrolytes are ordered in the recovery room and 12 h after surgery. Overnight, patients receive i.v. fluids, analgesics as necessary, prophylaxis for deep vein thrombosis with s.c. heparin, and antibiotic prophylaxis as per the hospital protocol. For the first 12–24 h after a large PN resection, patients have nil by mouth, and are placed on bed rest to minimize the risk of bleeding. The morning after surgery, the Foley catheter is removed, a clear liquid diet is started, and patients are encouraged to ambulate. Patients usually stay ≈2 days in the hospital.

STRATEGIES FOR CONTROLLING BLEEDING DURING SURGERY

During minimally invasive PN the rate of intraoperative haemorrhage has been reported to be 2–3.5% [4,15]. Bleeding can be from several sources and various techniques can be used to control it. Bleeding during dissection of the hilum or ureteric/gonadal vessels can generally be controlled using a lap pad or cottonoid to tamponade the bleeding while working on a different area for a few minutes. If a bleeding vessel is identified, a grasper can be used to occlude the vessel until cautery or clips control the bleeding.

Bleeding while on clamp can occur due to several reasons: (i) The main renal artery has a branch which was missed during clamping; or (ii) an accessory artery, usually from the adrenal, is still perfusing the kidney. For persistent bleeding, a long bulldog clamp can be placed across the renal hilum to encompass all branches of the artery, and another bulldog clamp placed in the fat between the kidney and the adrenal gland to occlude any accessory arteries. In addition, if the renal vein is clamped and unoccluded arterial inflow is suspected, the venous clamp can be removed to help alleviate renal congestion and improve vision. (iii) Older bulldog clamps can have decreased clamping

force, allowing perfusion to the kidney. In this case a second bulldog is placed. Pneumoperitoneum can temporally be increased to reduce bleeding as needed.

FROM SURGEON TO SURGEON

LPN has confirmed benefits for convalescence, and good functional and oncological outcomes. However, LPN is a challenging procedure requiring advanced skills. RPN can facilitate the technical challenges of LPN, potentially offering selected patients the benefit of minimally invasive surgery who might otherwise have had a total nephrectomy or open surgery. Robotic assistance can also help surgeons with no significant laparoscopic training to make the transition towards a minimally invasive approach for PN.

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Abbreviation: (L)(R)PN, (laparoscopic) (robotic) partial nephrectomy.