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Surgery Illustrated – Surgical Atlas
Zero-ischaemia robotic and laparoscopic partial nephrectomy (PN)

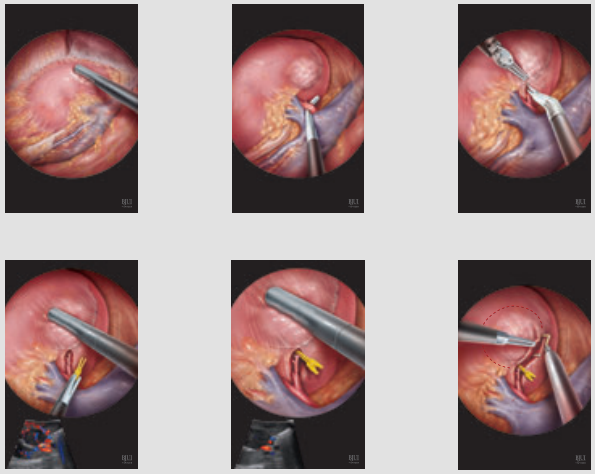
Mukul B. Patil and Inderbir S. Gill

Institute of Urology, University of California (USC), Los Angeles, California, USA

ILLUSTRATIONS by STEPHAN SPITZER, www.spitzer-illustration.com

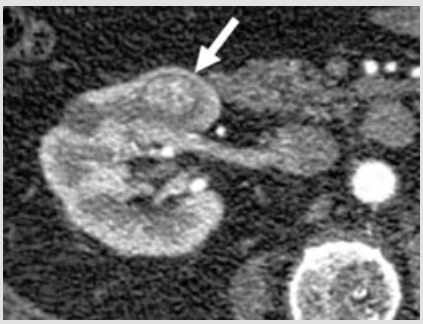
INTRODUCTION

In appropriate patients, partial nephrectomy (PN) offers equivalent oncological and superior functional outcomes compared with radical nephrectomy. In many tertiary centres worldwide with the requisite expertise, minimally invasive PN has emerged as the preferred approach. The deleterious impact of warm ischaemia during PN has been described, prompting the development of newer techniques, like early-unclamping, which minimize ischaemic insult to a mean of 14 min [1]. The latest advance in this laparoscopic and robotic evolution is zero-ischaemia PN, which allows excision of even technically challenging tumours without hilar clamping [2]. Our zero-ischaemia technique involves the basic concept micro-dissection of renal artery branches (tertiary or higher-order) with super-selective vascular control of the tumour and immediate peri-tumoral area. Even complex renal tumours (central, hilar, pT1b or tumour in a solitary kidney) can be resected safely with zero ischaemia in a minimally invasive fashion.



INDICATIONS

Enhancing renal mass deemed a candidate for PN.



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CONTRAINDICATIONS

- Morbid obesity (relative).
- Advanced age (>80–85 years).
- Significant comorbidity (cardiopulmonary, cerebrovascular).

PREOPERATIVE EVALUATION AND PATIENT PREPARATION

- Complete blood count.
- Comprehensive metabolic panel.
- 24-h urine collection (creatinine clearance, protein excretion).
- Abdomino-pelvic CT (0.5-mm cuts) to elucidate relationships between segmental/subsegmental arterial vasculature and the complex renal mass.
- Mercapto-acetyltriglycine (MAG-3) renal scan (differential renal function).
- Deep venous thrombus prophylaxis.
- Antibiotic prophylaxis.

SURGICAL EQUIPMENT

- Standard laparoscopic tray including: J-hook cautery, non-traumatic bowel graspers, scissors, right angle clamp.
- da Vinci robot with all accessory instruments (if PN is being done robotically).
- Vessel loops (Devon Dev-o-loops, Tyco Healthcare, Mansfield, MA, USA).
- Weck Hem-o-Lok clips (Teleflex Medical, Athlone, Ireland).
- Micro-vessel bulldog clamps (Aros Surgical, Newport Beach, CA, USA).
- 2-0 polyglactin CT-1.
- Number 1 polyglactin CTX with pre-pledgeted Weck Hem-o-Lok, 23 cm.

METHOD

We prefer the transperitoneal approach. Preoperative preparation includes cystoscopic placement of ipsilateral ureteric catheter, and intensive patient monitoring. After establishing pneumoperitoneum and placing ports, the colon is mobilized to reveal Gerota's fascia. For laterally based tumours, we no longer perform hilar mobilization. The renal hilum is carefully dissected with skeletonization of the renal artery and vein.

Hilar micro-dissection with scissors or J-hook cautery is then performed to isolate segmental secondary, tertiary or higher-order arterial branches. Ultra-fine CT (0.5-mm cuts) aids in identifying the targeted tertiary or higher-order arterial branch supplying the tumour or tumour-bearing segment of the kidney. Intraoperative ultrasound (US) is used to delineate margins of resection.

Power Doppler US is used before and after test-application of neurosurgical micro-bulldogs on the targeted tertiary vessel. This allows precise identification and isolation of the arterial supply to the mass in question; cessation of peri-tumoral intra-renal blood flow confirms that the targeted arterial branch has been occluded. Continued normal arterial flow in the remainder of the healthy kidney is documented. This eliminates ischaemic injury to collateral renal parenchyma.

When necessary, a small (1–2 cm) radial nephrotomy incision is created to facilitate exposure of specific intra-parenchymal vessels that directly supply the tumour. The entire renal hilum stays unclamped.

The tumour is excised with careful attention to maintain negative margins. The tumour is excised using a combination of J-hook electrocautery, cold scissors, and Hem-o-Lok clips. During tumour excision, uninterrupted global renal perfusion is maintained.

Suture renorrhaphy is performed without hilar clamping. First, the collecting system is interrogated with a retrograde ureteric injection. Any pelvi-calyceal defect is closed with a 2-0 CT-1 polyglactin suture. Next, parenchymal reconstruction is performed with pre-pledgeted, number 1 CTX polyglactin horizontal mattress suture. Floseal®, with or without a Surgicel® bolster, is used. The super-selectively placed micro-bulldogs are removed and haemostasis confirmed.

Figure 1

Laparoscopic US probe.

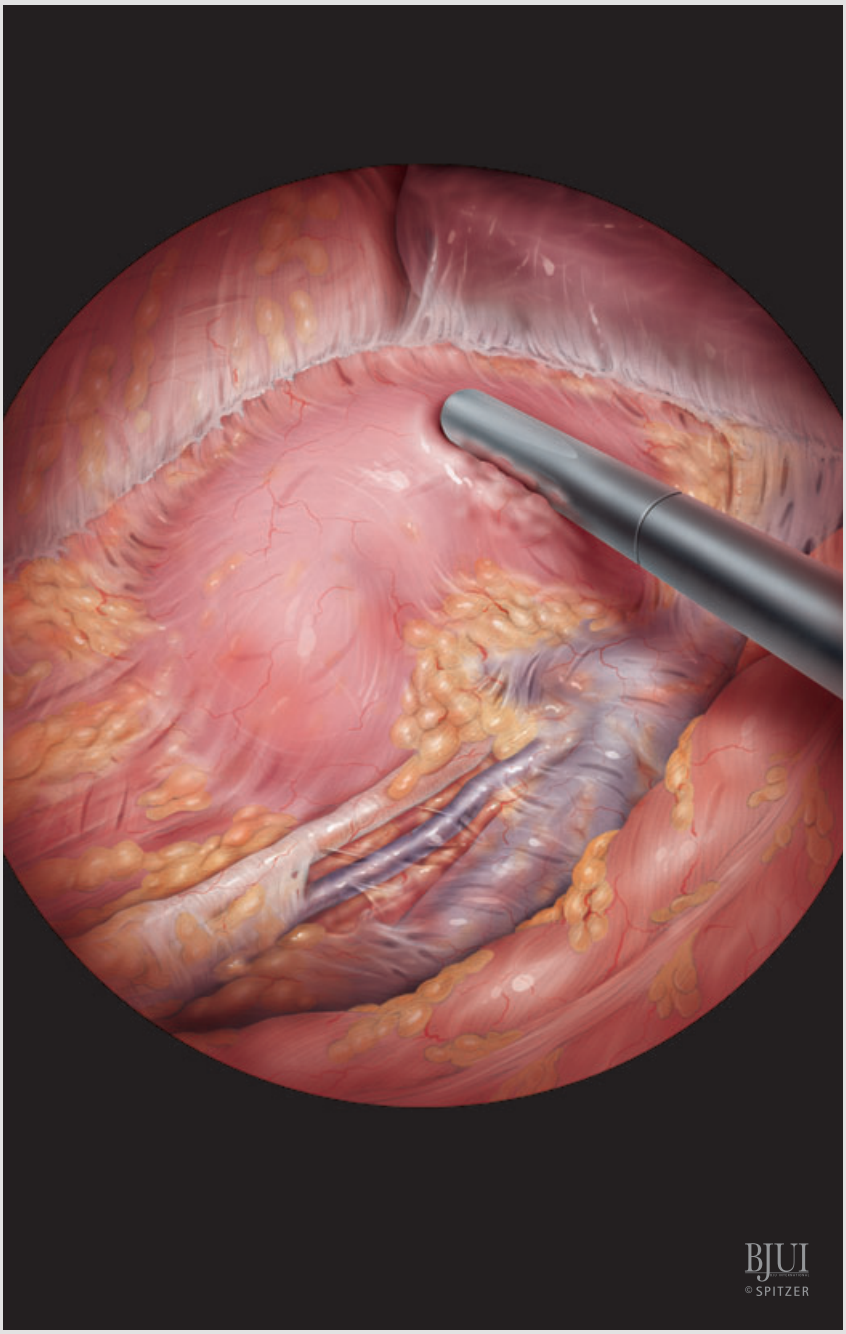


Figure 2

Hilar micro-dissection with right-angle clamp.

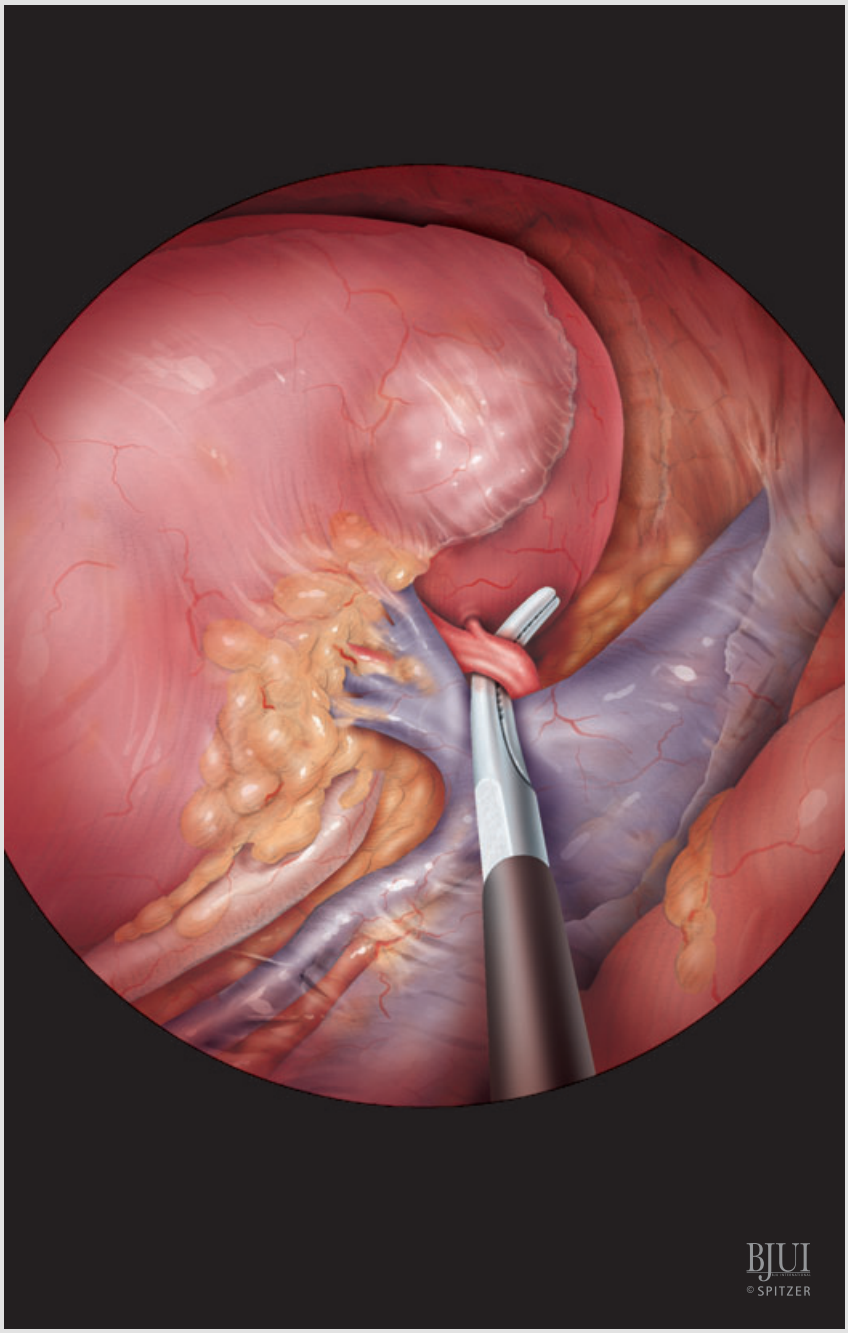


Figure 3

Small radial nephrotomy (1–2 cm) made with scissors or J-hook cautery, exposing the intra-renal arterial branch supplying the tumour.

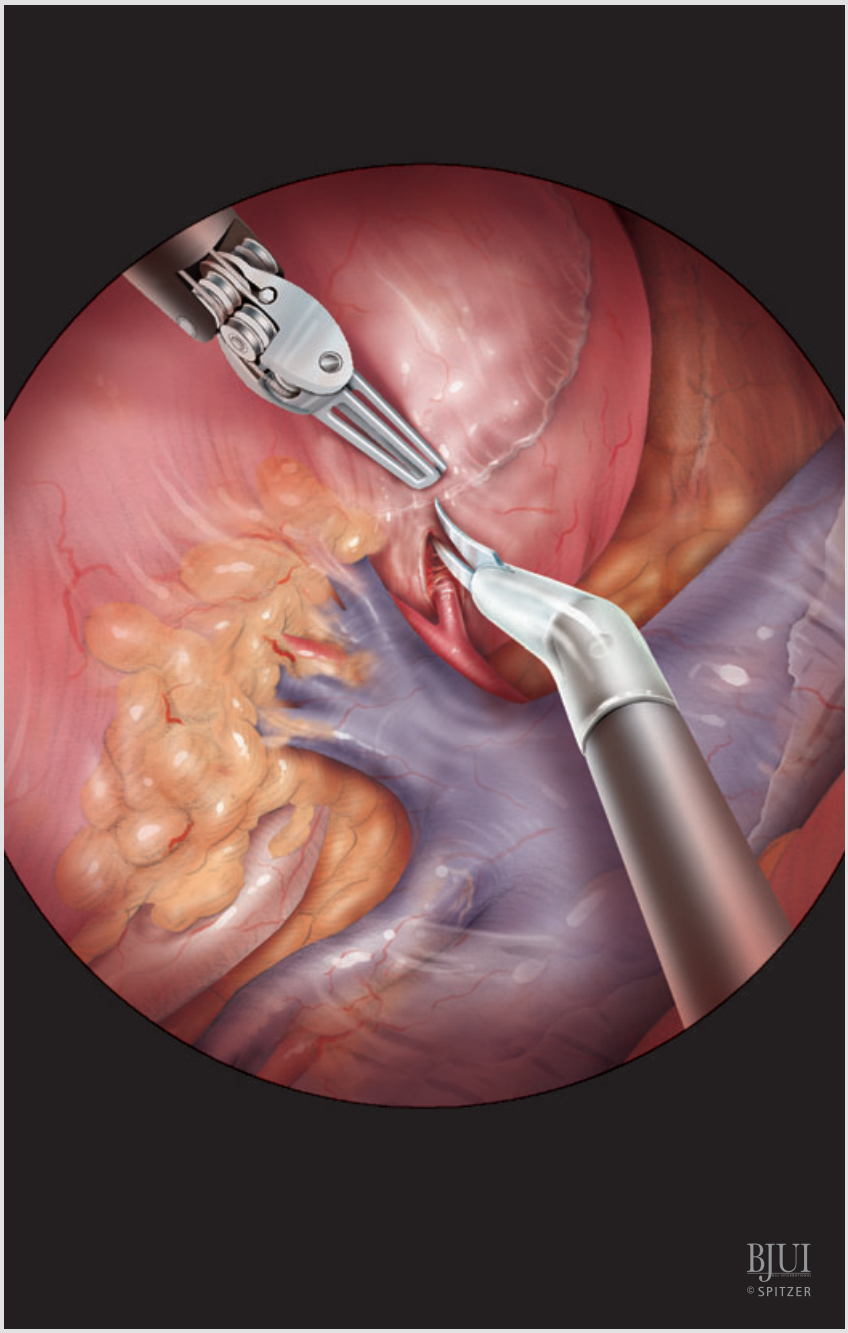


Figure 4

Intraoperative colour-Doppler US showing presence of peri-tumoral Doppler flow.

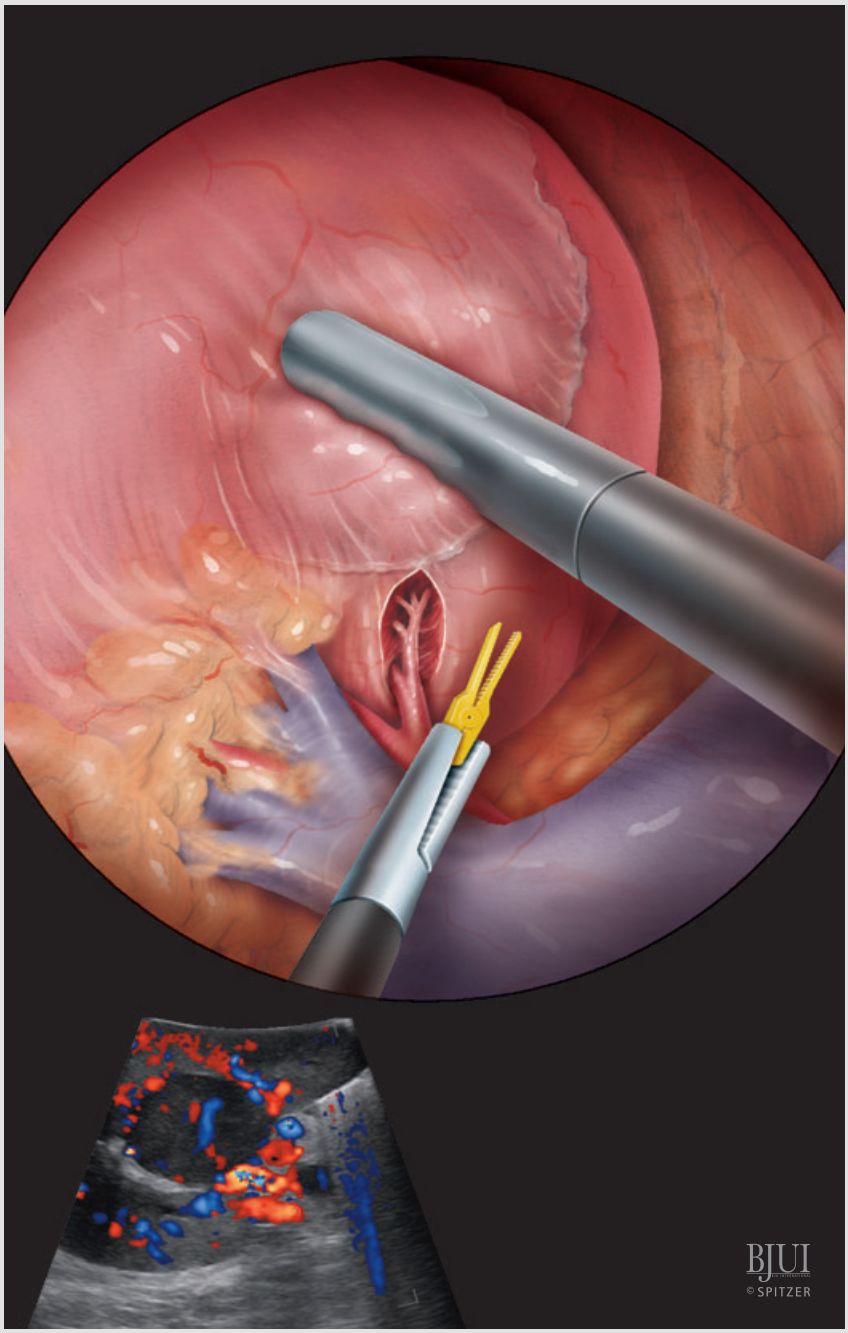
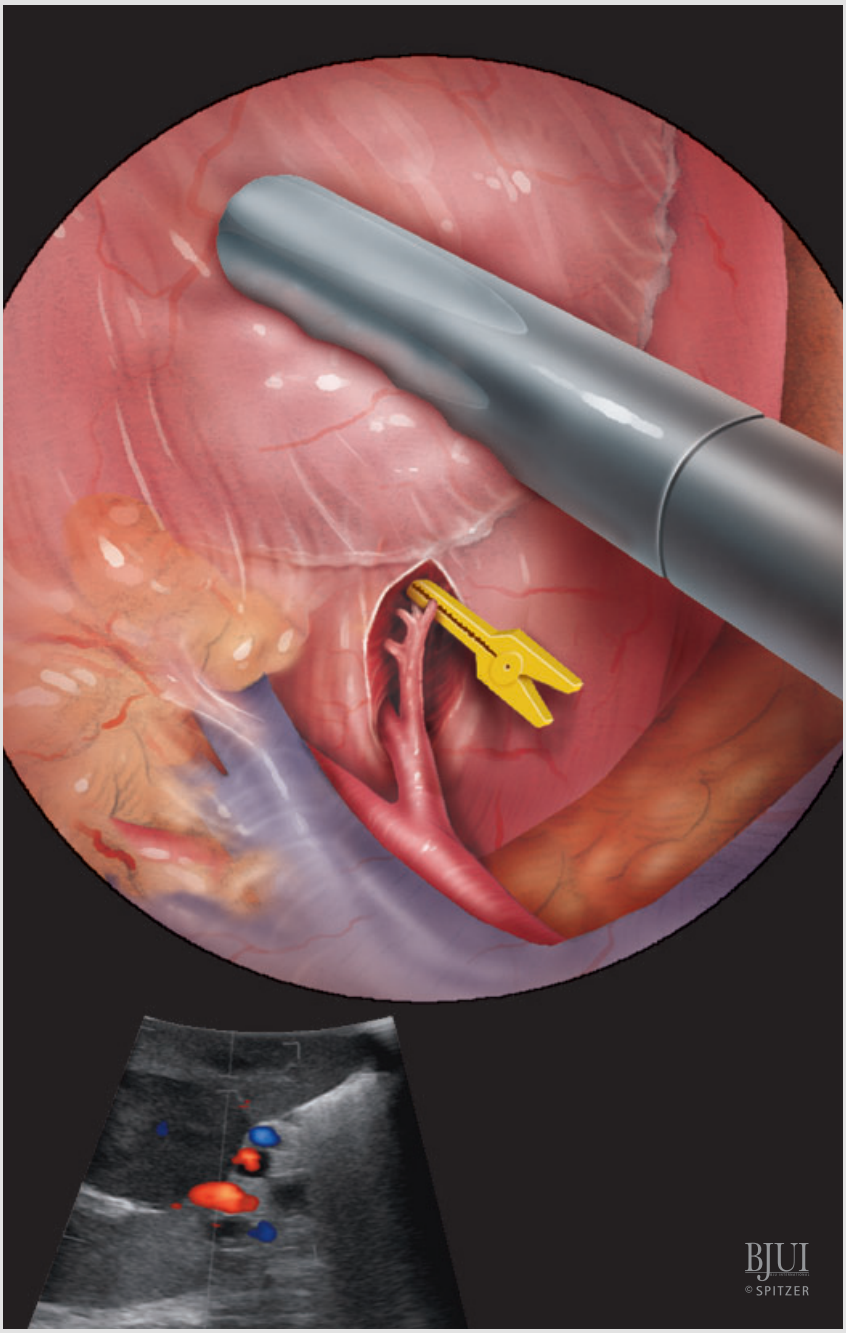


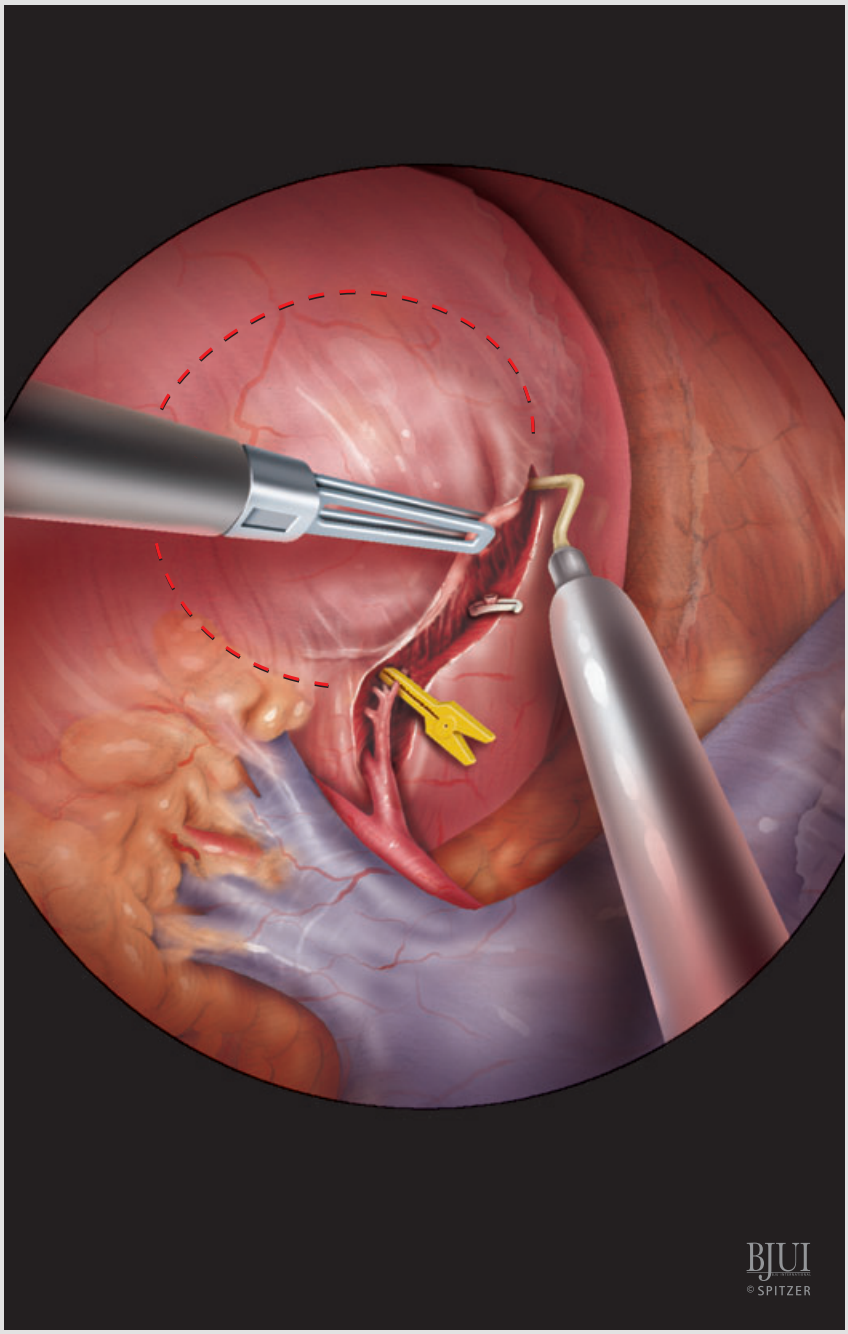
Figure 5

Intraoperative US showing cessation of peri-tumoral Doppler flow after super-selective placement of micro-bulldog clamp.



Figures 6 and 7

Tumour resection occurs with a combination of monopolar cautery and sharp excision without interruption of global renal perfusion.



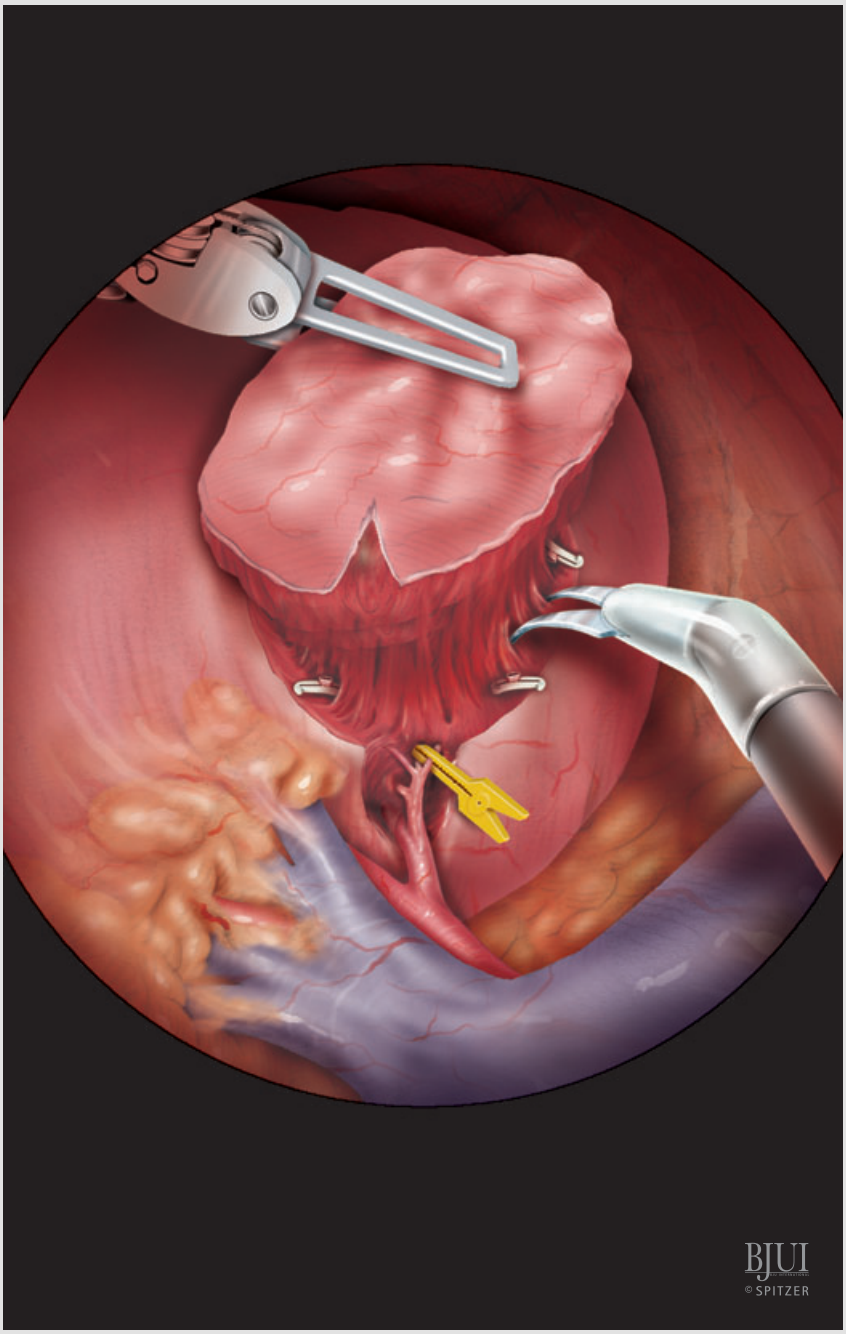


Figure 8

Any pelvi-calyceal defect is closed with a 2-0 CT-1 polyglactin suture.

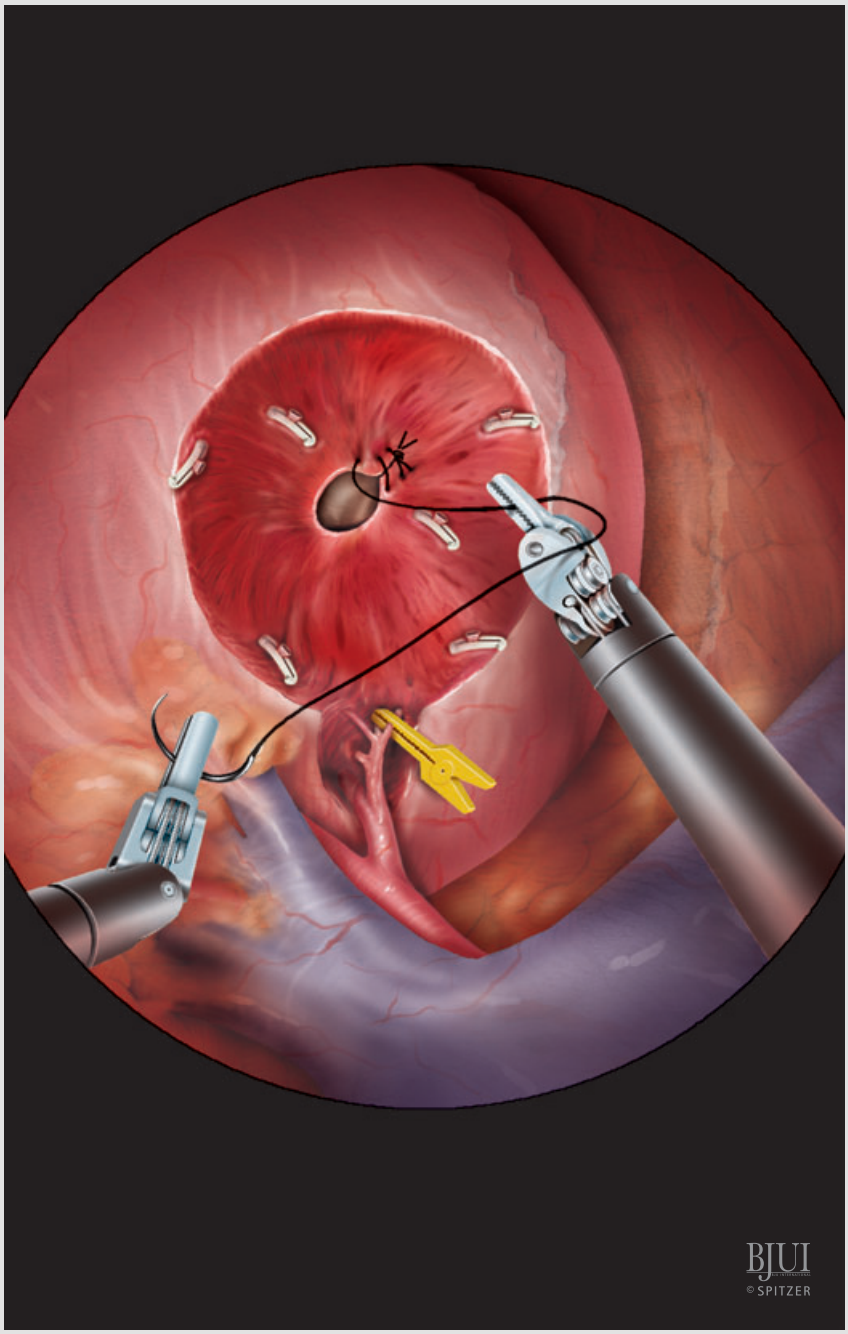


Figure 9

Suture renorrhaphy with polyglactin suture is performed.

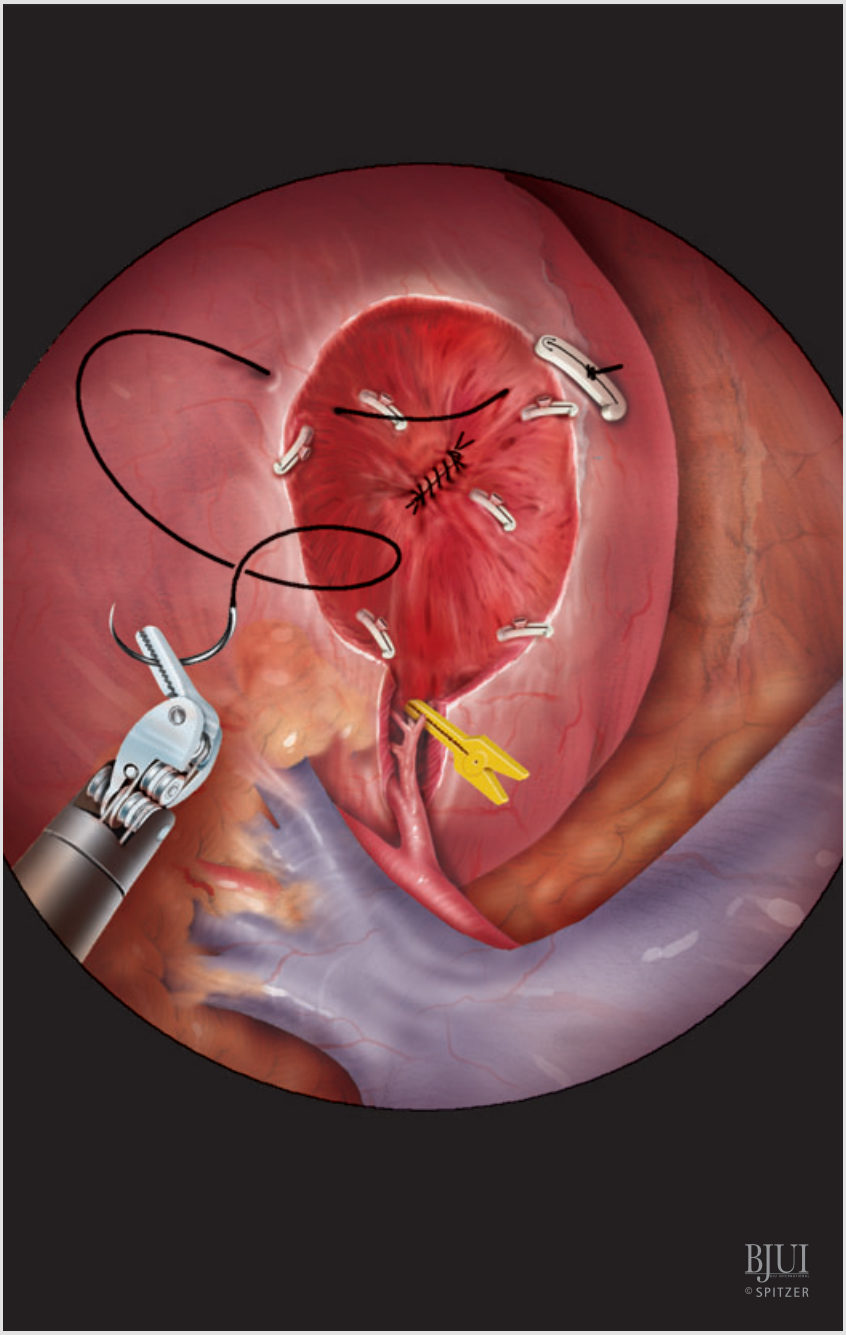
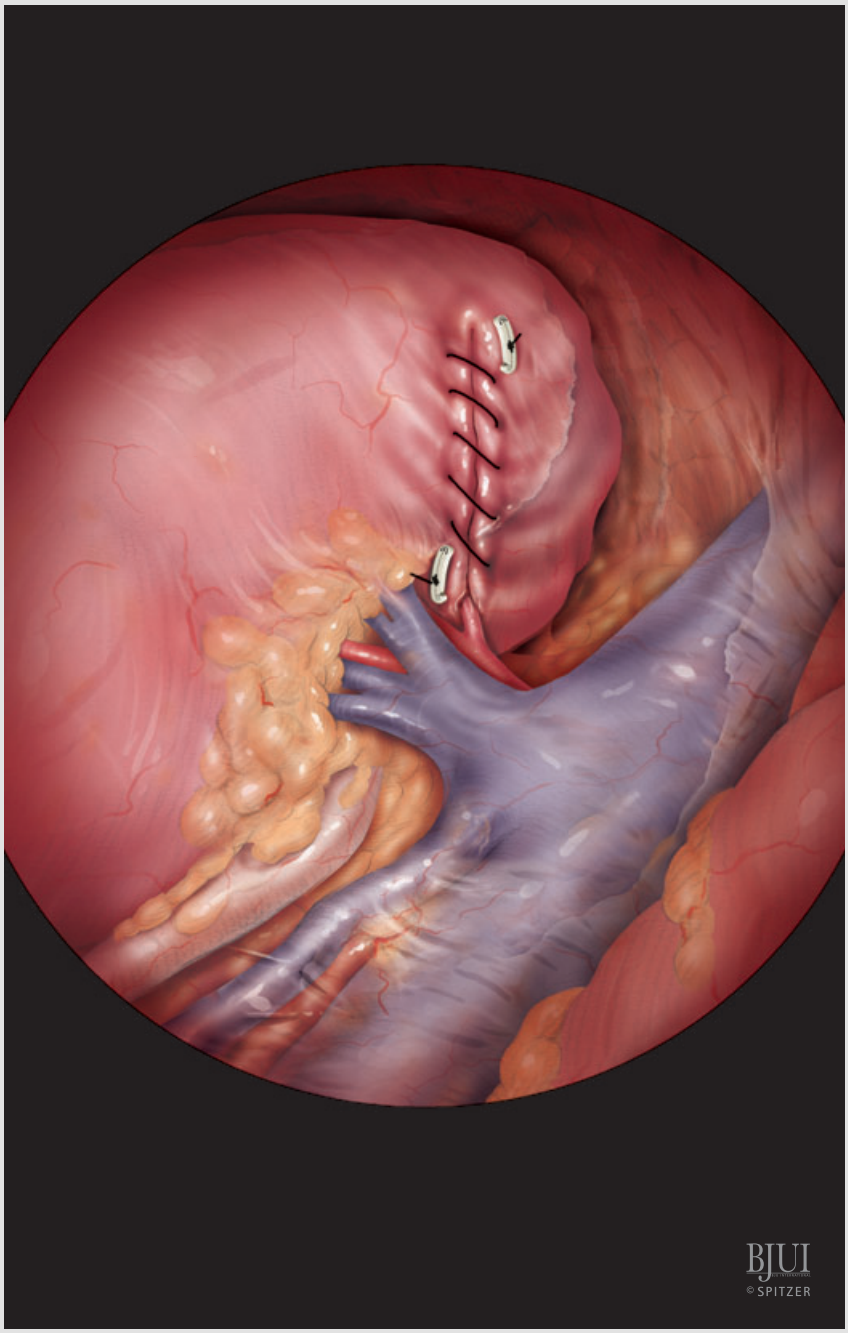


Figure 10

Completed zero-ischaemia surgery for a completely intra-parenchymal, central, hilar tumour, deep in the mid-portion of the kidney.



POSTOPERATIVE CARE

Patients are monitored closely postoperatively, and aggressive diuresis is performed. A clear liquid diet is maintained until evidence of bowel function, after which a regular diet is permitted. Perioperative antibiotics are continued for 24 h, and s.c. anticoagulation, started preoperatively, is continued postoperatively. Oral and i.v. narcotics are used for pain control. The ureteric catheter is removed in the morning of the second postoperative day. A closed-suction surgical drain is maintained until output is <50 mL daily for 3 consecutive days and fluid analysis reflects absence of urinary leak.

FUTURE CONSIDERATIONS

Our initial experience with zero-ischaemia robotic/laparoscopic PN is encouraging. We have been able to excise even complex tumours (completely intra-parenchymal, central, hilar, multifocal tumours, tumour in a solitary kidney or recurrent tumour after previous PN) without hilar clamping or any global warm ischaemia. With experience, we routinely use the novel techniques of hilar micro-dissection and super-selective vascular control for resection of tumours >4 cm (clinical T1b, select T2 renal masses). Preoperative surgical planning for complex renal tumours requires ultra-fine CT with 0.5-mm cuts. We have recently used these detailed studies to develop augmented reality for preoperative planning and intraoperative predictive mapping.

CONCLUSIONS

Zero-ischaemia robotic and laparoscopic PN represents the latest minimally invasive approach for nephron-sparing surgery, by allowing safe tumour resection of complex masses. With this approach, global renal ischaemia is now unnecessary during robotic and laparoscopic PN. As a result, in the senior authors' tertiary referral practice over the past 12 months, >98% of all consecutive PNs have been performed without any hilar clamping.

REFERENCES

1 **Nguyen MM**, **Gill IS.** Halving ischemia time during laparoscopic partial nephrectomy. *J Urol* 2008; **179**: 627–32
2 **Gill IS**, **Eisenberg MS**, **Aron M** ***et al*****.** 'Zero ischemia' partial nephrectomy: novel laparoscopic and robotic technique. *Eur Urol* 2011; **59**: 128–34

Correspondence: Mukul Patil, USC Institute of Urology, 1441 Eastlake Ave, Ste 7416, Los Angeles, California 90089, USA.
e-mail: mpatil@usc.edu

Abbreviations: **PN**, partial nephrectomy; **US**, ultrasound/ultrasonography.