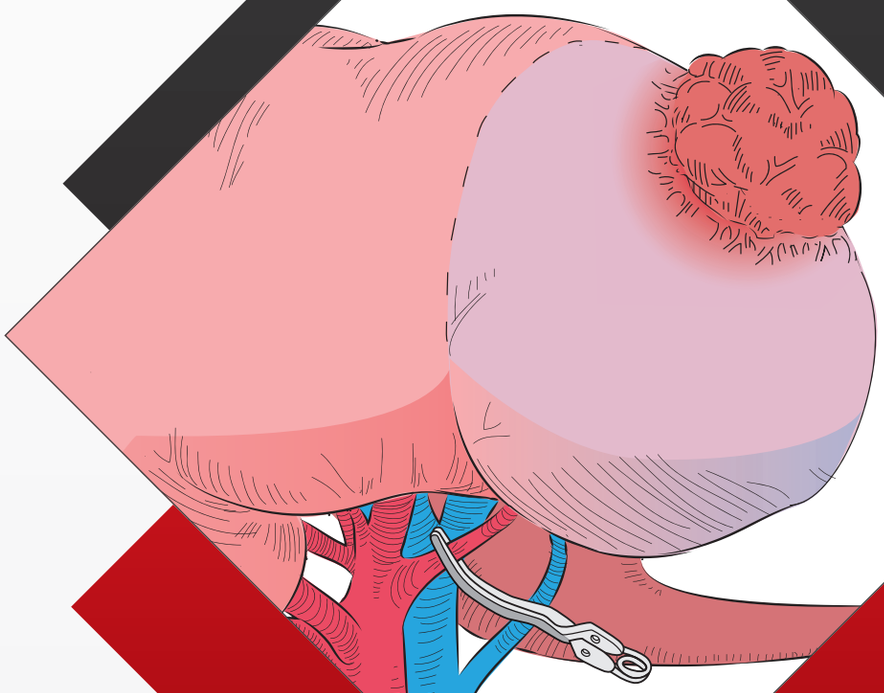
STEP-BY-STEP

LAPAROSCOPIC PARTIAL NEPHRECTOMY



MAIN AUTHOR
Dr Allen Sim

CO-AUTHORS
Dr Henry Ho
Dr Kenneth Chen
Dr Albert Bosch
Dr Lee Han Jie
Dr Henry Lim

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FOREWORD

Urology as a surgical subspecialty takes root in Singapore when the Department was established in Singapore General Hospital (SGH) by Professor Foo Keong Tatt in 1988. As the first and largest Urology Department in Singapore, we have since grown from strength to strength, striving towards surgical excellence in the spirit of providing the best care for our patients. Keeping abreast of global trends in surgical management of renal masses and the increasing utilisation of minimally invasive techniques, our department had adopted MIS techniques for nephrectomy since the 2000s.

Laparoscopic partial nephrectomy however remains a demanding surgery requiring advanced techniques and laparoscopy skills. This updated curriculum includes the best practices acquired through many years of experience accumulated in the SGH Urology Centre. It is a much awaited move to consolidate the best practices, tips, and tricks into a user-friendly manual. This book culminates the department's educational efforts in facilitating the learning curve of any urologist as they aspire to enhance their skills in the surgical management of kidney cancers.

We hope this book will inspire, enlighten and encourage the reader to pursue excellence in field of laparoscopic partial nephrectomy.

Assoc Prof Henry Ho Sun Sien
MBBS (S'pore), MRCS (Singapore), MMed (Surgery), FAMS (Urology)
Head & Senior Consultant,
Department of Urology,
Singapore General Hospital

The Laparoscopic Partial Nephrectomy Workshop was the first in Southeast Asia, that was spearheaded by SGH Urology in 2016. It aims to provide high quality masterclass in advanced nephrectomy concepts such as, standard laparoscopic partial nephrectomy and ICG assisted super-selective clamping in partial nephrectomy. It includes a select group of participants to ensure appropriate level of interaction with the faculties. The live surgery's moderation allows opportunity for discussion and window to understand the surgeon's decision process during the surgery. The second day of the workshop is a hands-on animal sessions for participants to practice what they have learnt.

Beyond technical knowledge, this workshop also provides a platform for many expert laparoscopic urologists to share their unique and difficult cases and exchange their tip and tricks. Many new friendships have been forged and consolidated into this network of Asian laparoscopic urologists. The curriculum for this workshop has received high accolades from the attendees and is an education model for delivering high-value learning experience in laparoscopic partial nephrectomy.

Dr Kenneth Chen
MBBS (Singapore) MCI (Singapore), FRCS (Glas), FAMS (Urology)
Organising Chairman, Laparoscopic Partial Nephrectomy Workshop
Department of Urology,
Singapore General Hospital

AUTHOR BIOGRAPHY

Dr Allen Sim
MRCS (Edin), FAMS (Singapore), FRCS (Glasg)
Consultant Urologist,
Department of Urology,
Singapore General Hospital

Dr Sim is a Consultant with the Department of Urology at the Singapore General Hospital. He graduated with honours from University College Dublin in 2005 and completed his advanced traineeship in Urology in 2014 with the Department of Urology, Singapore General Hospital. Dr Sim has presented at various local and international conferences, as well as an invited speaker and faculty to various international conferences.

In 2014, Dr Sim was awarded a fellowship at the Eberhard Karls University of Tuebingen (Germany) with Prof Christian Schwentner, sub-specialising in Endourology, Laparoscopic and Robotic Surgery. He has a keen interest in management of urinary stone diseases and minimally invasive surgeries for bladder, kidney and prostate. The list of sub-specialiSed procedures Dr Sim is trained in include: mini PCNL (Percutaneous Nephrolithotomy), wide range of laparoscopic surgeries such as laparoscopic radical nephrectomy, nephroureterectomy, partial nephrectomy, pyeloplasty, retroperitoneal lymph node dissection (RPLND), IVC thrombectomy as well as robotic partial nephrectomy, prostatectomy and radical cystectomy with special interest in intracorporeal urinary reconstruction. Since returning from his fellowship, he has played a big role in advancing minimally invasive surgeries and pioneering surgical techniques such as supine PCNL, ECIRS, Video Endoscopic Inguinal Lymphadenectomy (VEIL) and zero ischaemic partial nephrectomy with super-selective clamping.

CONTENTS

INTRODUCTION AND BACKGROUND

NATURAL HISTORY OF SMALL RENAL MASS

The incidence of incidental small renal masses (SRM) has been increasing over the last two decades due to the use of modern imaging procedures such as ultrasonography and computed tomography (CT).[1] Not all SRMs are Renal Cell Carcinoma (RCC), with about 20%–30% of SRMs being benign.[2] Recent systematic review showed the mean linear growth rate of SRM is 0.33cm/year and the rate of metastasis is below 2%.[3] However, not all SRMs are the same and growth kinetics may be variable and imperfect as a predictor of outcomes.[4] Some factors are associated with growth rate of SRMs, including tumour grade, histological subtype, initial tumour size and patient's age.[5]

INDICATIONS

Partial nephrectomy has been shown to have equivalent oncologic control compared to radical nephrectomy with added benefits of renal parenchymal preservation as well as improved overall survival.[6,7]

Indications for PN can be categorized into:

1. Imperative
   This would include circumstances in which a radical nephrectomy would render the patient anephric, with resultant need for immediate renal replacement therapy.

   Such scenarios include:
   - Solitary kidney—anatomical or functional
   - Bilateral renal masses
   - Chronic renal insufficiencies

2. Relative
   Conditions that fall into this category include those with pre-existing renal disease with an imperfect function, or if the contralateral kidney is expected to suffer insufficiency in future.

   Conditions that fall into this category include:
   - stone disease
   - chronic pyelonephritis
   - renal artery stenosis
   - vesicoureteral reflux (with or without renal scarring)
   - chronic renal obstruction from congenital or acquired causes
   - systemic diseases like diabetes, hypertension and nephrosclerosis

3. Elective
   These are cases where the kidneys are healthy with normal renal function

Partial nephrectomy is traditionally offered in tumour less than 4cm. However, with increasing experience, more complex partial nephrectomy can be performed; bilateral PNs, multiple tumours, tumours larger than 4cm, hilar masses as well as endophytic tumours.[8,9]

CONTRAINDICATIONS

Laparoscopic partial nephrectomy (LPN) is relatively contraindicated for patients with previous extensive abdominal surgeries and a high Body Mass Index (BMI). However, retroperitoneal laparoscopic approach can be considered in patients with previous abdominal surgeries.

LPN is not recommended in patients with tumours that would prevent the surgeon achieving negative surgical margins. This includes patients with extensive renal masses or extension into the renal vein, perinephric fat or renal sinus fat or inferior vena cava even though the tumour size may be small (<4cm).

We recommend that surgeons early in their laparoscopic training seek supervision from trained mentors prior to attempting the procedure.

PRE-OPERATIVE PREPARATION

PRE-OPERATIVE IMAGING

A CT or MRI scan is required for accurate staging and clarification of tumour complexity. Anatomical scoring system is imperative in deciding treatment options and approaches to LPN. One of the most well-established scoring system is the R.E.N.A.L. nephrometry score which is based on five parameters: radius, exophytic/endophytic, nearness to the collecting system, anterior/posterior and location relative to the polar lines.[10] There are various other scoring systems such as PADUA, centrality index as well as contact surface area (CSA).[11] Intraparenchymal Volume (IPV) is a novel scoring system developed in Singapore General Hospital based on the hypothesis that the amount of tumour that is intraparenchymal determines the complexity of the PN. Initial results are encouraging in which IPV has been shown to correlate well with existing R.E.N.A.L. score.[12] Higher IPV has also been shown to correlate with worse perioperative renal outcomes.[12]

ANAESTHETIC CONSIDERATIONS

- GA with ETT insertion
- Nasogastric tube is not necessary, orogastric tube is optional

OPERATION THEATRE SETUP

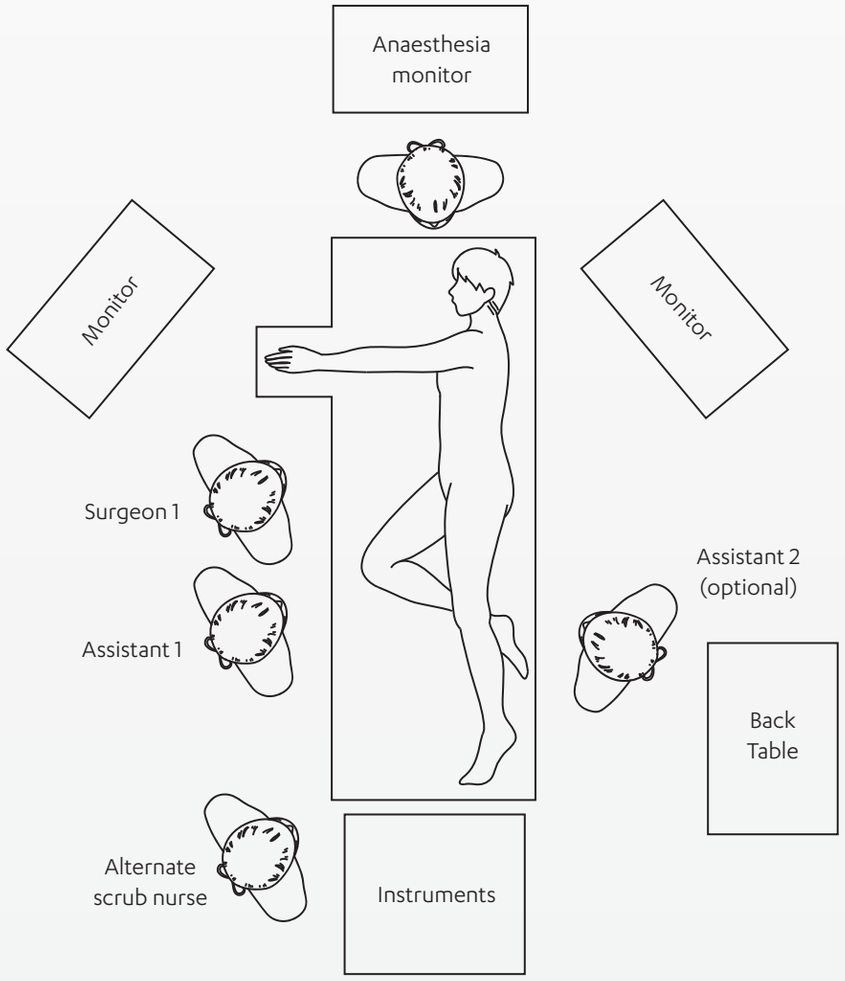

Figure 1. Operation theatre setup

EQUIPMENT

		ITEM DESCRIPTION	ITEM CODE
ACCESS	**Access**	ENDOPATH XCEL® Trocars with OPTIVIEW® Technology 12mm x 100mm	2B12LT
		ENDOPATH XCEL® Trocars 5mm x 100xx	B5LT
REPAIR	**Mobilisation**	HARMONIC™ HD 1000i Shears 36cm	HARHD36
		Laparoscopic Maryland Dissector	
		Endopath® 5mm Curved Scissors with Monopolar Cautery	5DCS
		Laparoscopic Ratchet Grasper	
		ENDOPATH® Electrosurgery Probe Plus II Pistol Hand Control	EPH02
		ENDOPATH® Electrosurgery Probe Plus II 5mm - Spatula - 34cm	EPS02
	Clamping	Laparoscopic Vascular Bulldog Clips	
	Excision	Endopath® 5mm Curved Scissors with Monopolar Cautery	5DCS
		HARMONIC™ HD 1000i Shears 36cm	HARHD36
	Renorraphy	3-0 STRATAFIX™ SPIRAL MONOCRYL® PLUS UNDYED 20cm SH	SXMP1B427
		1 COATED VICRYL® PLUS VIOLET 1 x 36" CT	VCP359H
		Hem-o-lok® LIGATING CLIPS: LARGE, 6 CLIPS/CARTRIDGE	
		Hem-o-lok® Endo10® LARGE CLIP APPLIER, 32cm	
	Specimen retrieval bag	ENDOPOUCH RETRIEVER® Disposable Specimen Retrieval Bag 4" x 6"	POUCH
	Adjunctive haemostats	SURGICEL SNoW® 5.1cm x 10.2cm	2092
		EVICEL® Fibrin Sealant (Human) 2ML KIT + EVICEL® DEVICE 1ml/2ml	EVB02SGPH + EVD0102
		EVICEL® Airless Spray Accessory	EVTASLR
CLOSURE	**Wound closure**	2-0 COATED VICRYL® PLUS VIOLET 1 x 27" UR-6	VCP602H
		DERMABOND ADVANCED® Topical Skin Adhesive	ANX12

PATIENT POSITIONING AND PORT PLACEMENT

- Preoperative ureteric stenting is not routinely practised
- Foley catheter insertion
- Full lateral position; axillary roll insertion and ensure all pressure points are padded
- Flex the table to open and flatten the flank

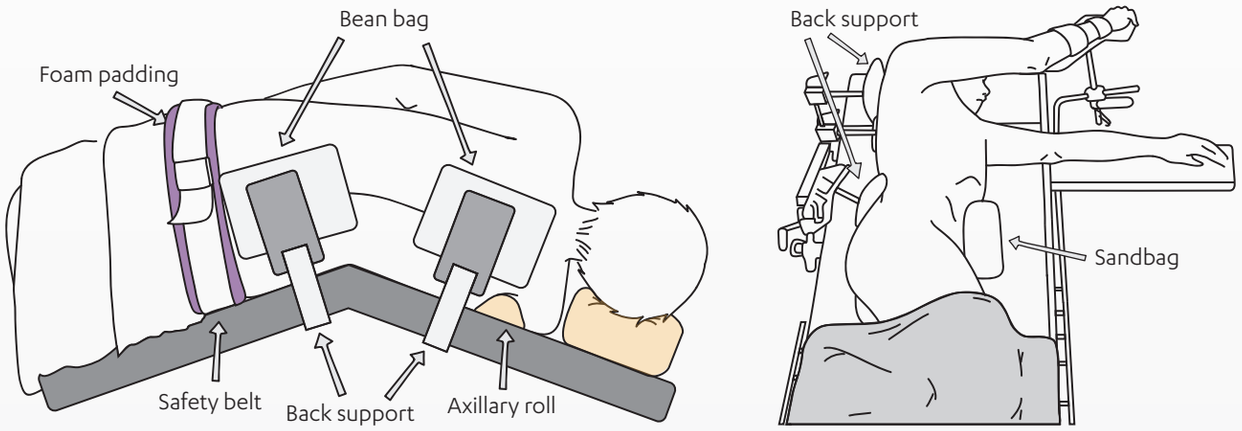

Figure 2. Pressure point padding during anaesthesia: Left) Back view, right) Lateral view

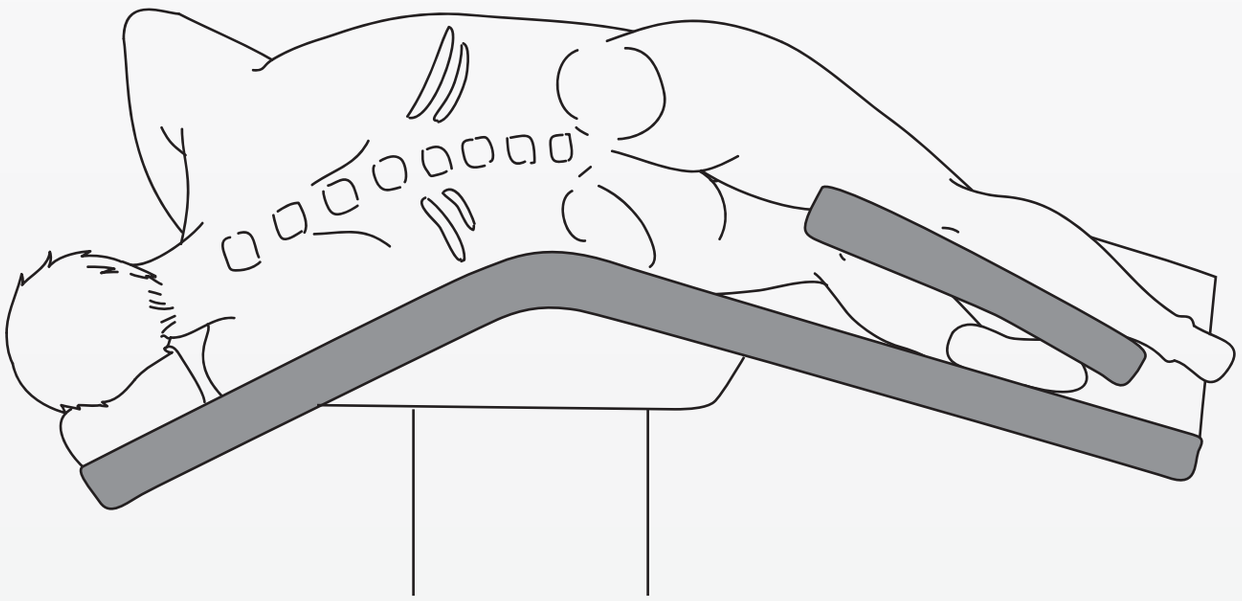

Figure 3. Flexing the operating table to flatten the flank for greater exposure and excursion of laparoscopic instruments

PORT PLACEMENT

The placement of the camera port and the left and right-hand working ports follows the general principle of triangulation with minor variations for certain tumour locations or habitus of the patient.

The right-hand port is a 12mm port to facilitate needle passage and hem-o-lok® application. The left hand port can be a 12mm port as well to increase versatility but the author's preference is a 5mm port. The addition of a kidney retraction port in the lateral lumbar region as well as a liver retraction port just distal to the xiphisternum for right sided tumours typically involve a 5mm port.

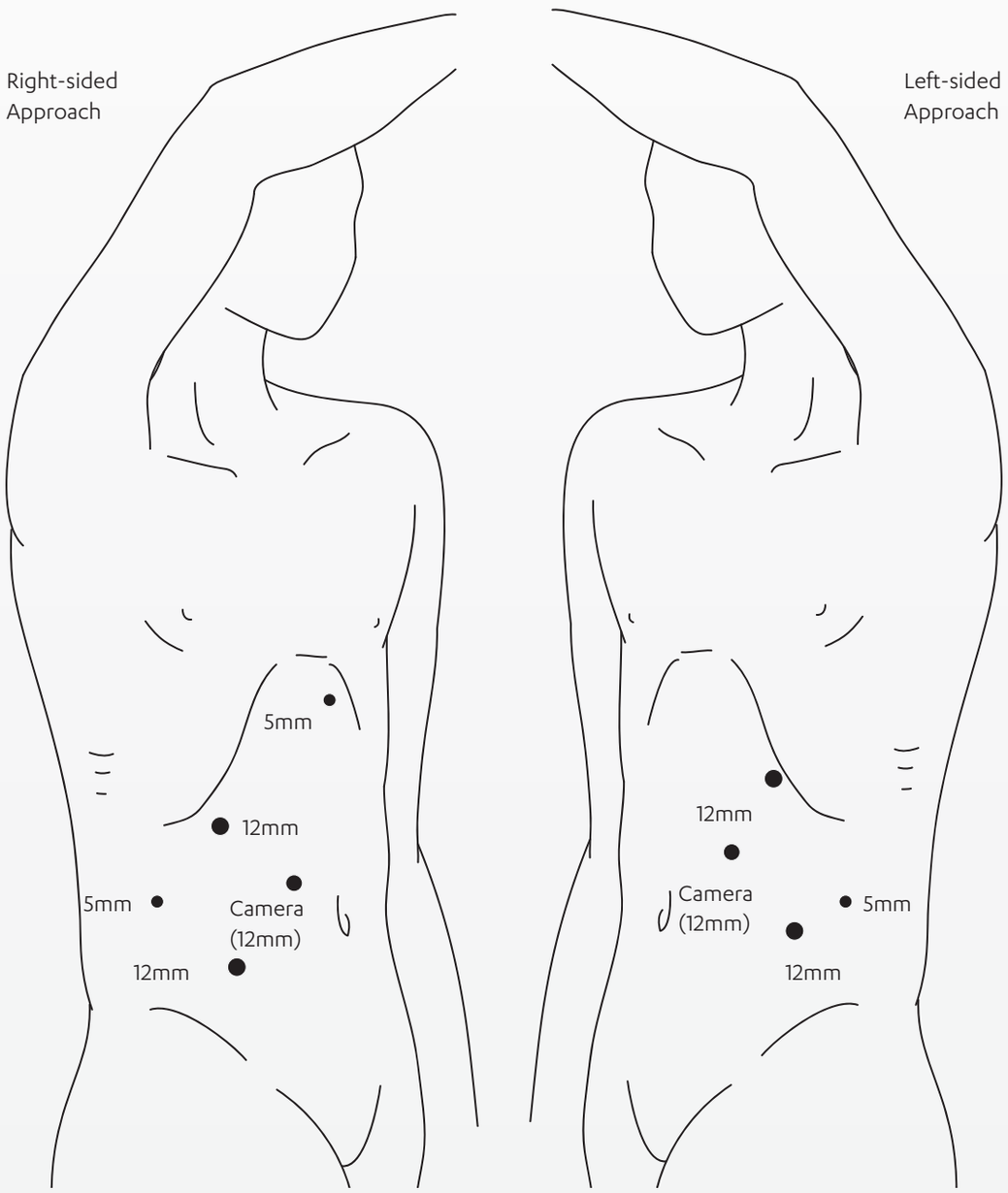

Figure 4. Port placements

SURGICAL TECHNIQUE

We will describe step-by-step the surgical technique of laparoscopic partial nephrectomy via transperitoneal approach.

1. MEDIAL MOBILISATION OF COLON

The Gerota's Fascia of kidney is exposed by incising along the white line of Toldt. Gerota's fascia can be identified as a glistening white layer and a combination of blunt and sharp dissection is used to develop the avascular plane between the Gerota's fascia and posterior mesocolon.

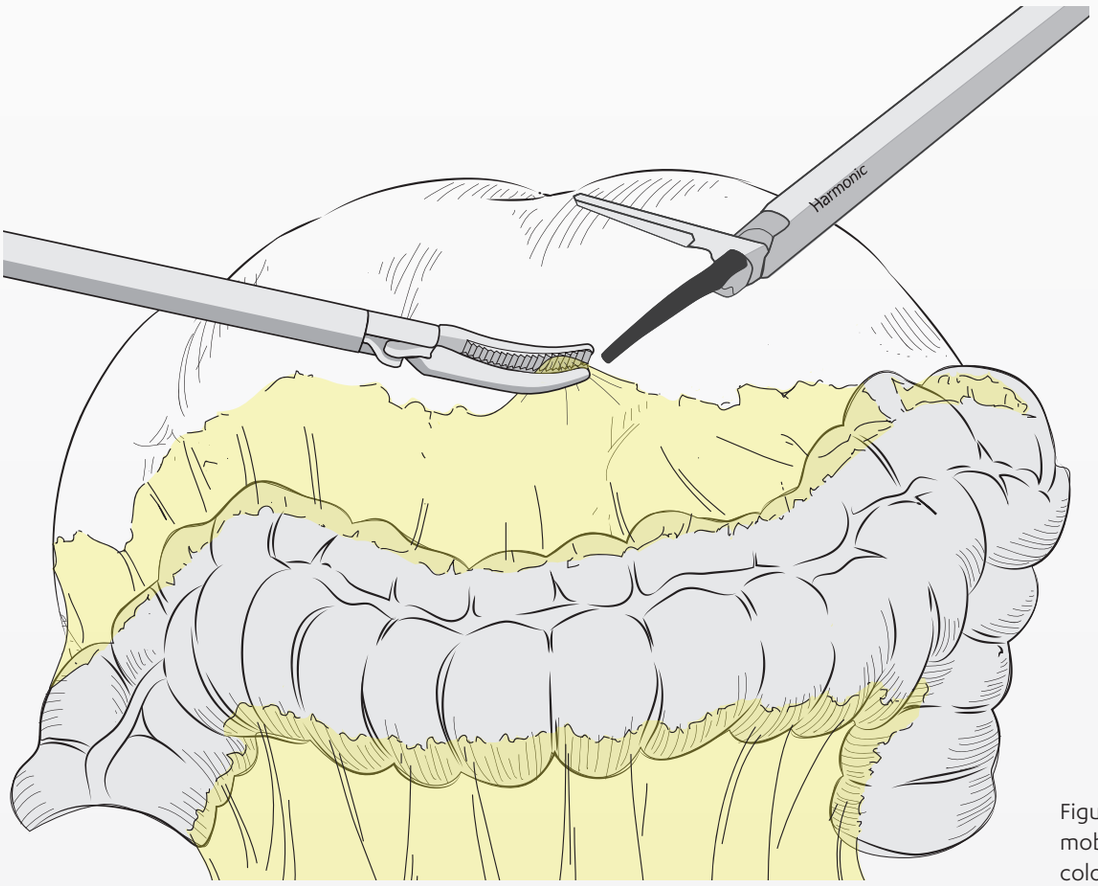

Figure 5. Medial mobilisation of colon

2. MOBILISATION OF SURROUNDING STRUCTURES

On the right side, careful kocherisation of duodenum is performed using cold scissors. Diathermy or energy devices should be avoided to prevent thermal injury to the duodenum. The attachments to the spleen and liver are also released. The liver can be retracted by inserting a racheted grasping forceps through a 5mm port just inferior and lateral to the xiphisternum.

3. IDENTIFICATION OF GONADAL VEIN AND PSOAS MUSCLE

After adequate medial mobilisation of the colon, the first structure that is usually visible is the gonadal vein. A combination of sharp and blunt dissection above the gonadal vein just caudal to lower pole of kidney should allow identification of psoas muscle. An additional port can be inserted to retract the ureter if necessary. Care is taken not to skeletonise the ureter to avoid ureteric injury and potential long-term ureteric stricture. The gonadal vein is preserved in most cases. However, it can be ligated and divided if bleeding from the vein is encountered during dissection.

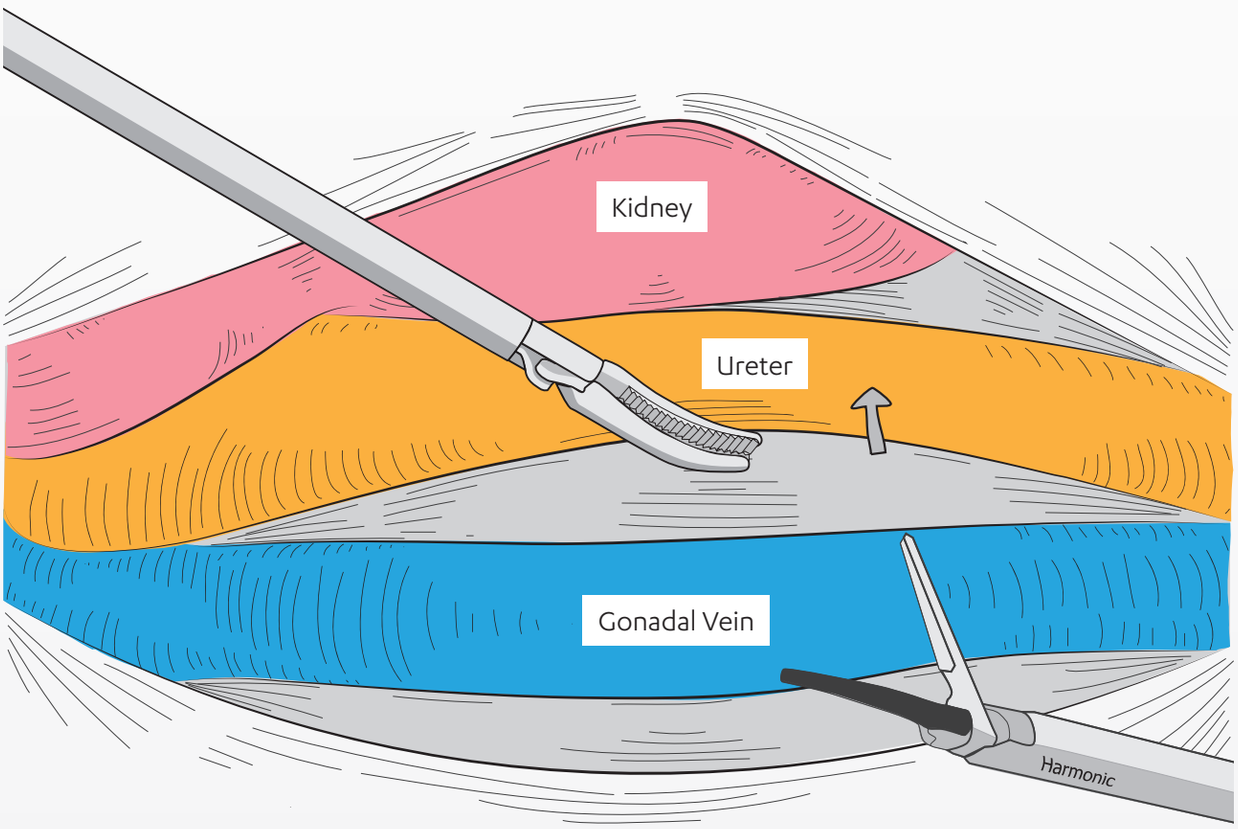

Figure 6. Identification of gonadal vein

SURGICAL TECHNIQUE

4. HILAR DISSECTION

Dissection is continued along the psoas muscle towards the hilum. It is important at this stage to keep the kidney stretched under tension to improve identification and subsequent dissection of the hilar structures. The renal vein can be identified by tracing the gonadal vein cranially to its insertion in the renal vein on the left side or its insertion in the inferior vena cava near the right renal vein on the right side. The renal artery is usually posterior to the renal vein. Pre-operative imaging is useful in locating the renal artery and identification of aberrant renal arteries. The renal artery is carefully dissected and slung in preparation of clamping. Dissection of tertiary branches can be performed if super-selective clamping is planned. Renal vein dissection is usually not done as it is not routinely clamped. Renal vein clamping can be considered for large hilar tumours. Near Infrared Fluorescence Imaging (NIRF) with Indocyanine Green (ICG) can be utilised in identification of complex hilar anatomy as well as tertiary arterial branches.[13]

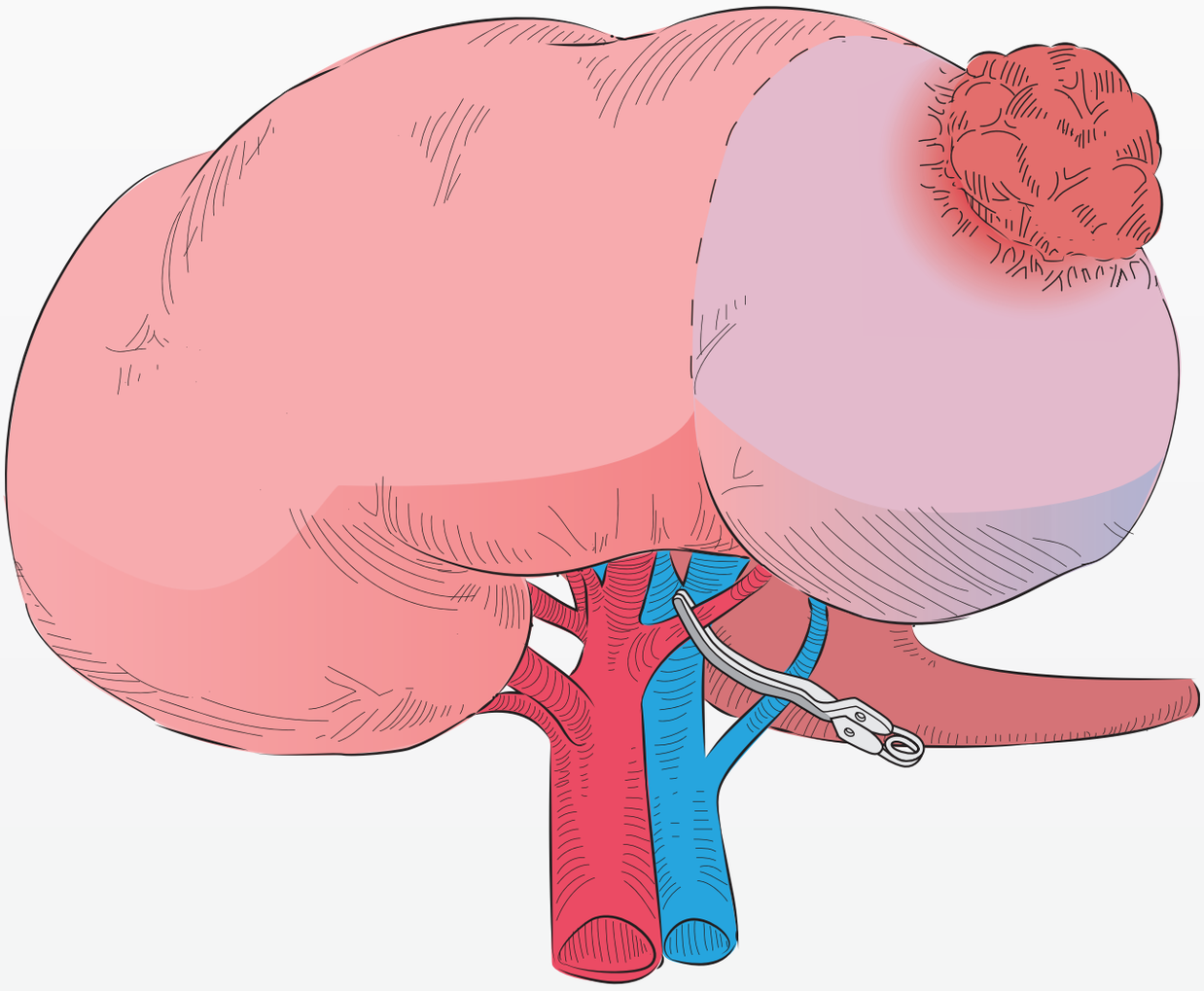

Figure 7. Hilar dissection

5. MOBILISATION OF KIDNEY, EXPOSURE OF TUMOUR, SCORING OF RESECTION MARGIN WITH HELP OF INTRA-OPERATIVE ULTRASOUND

After hilar dissection, Gerota's fascia is incised to expose the tumour and surrounding renal capsule. Adequate mobilisation is essential to ensure the tumour is optimally placed for easier resection and renorrhaphy. In the case of endophytic tumour, intraoperative ultrasound can be used for tumour identification. The resection margins are also identified using ultrasound and marked with cautery.

When "toxic" fat is encountered, careful and meticulous dissection is performed to avoid entering the tumour or tearing the renal capsule. Presence of tactile feedback in laparoscopic surgery is useful to help guide the dissection by 'feeling' for the tumour. Intra-operative ultrasound can also be used to help locate the tumour.

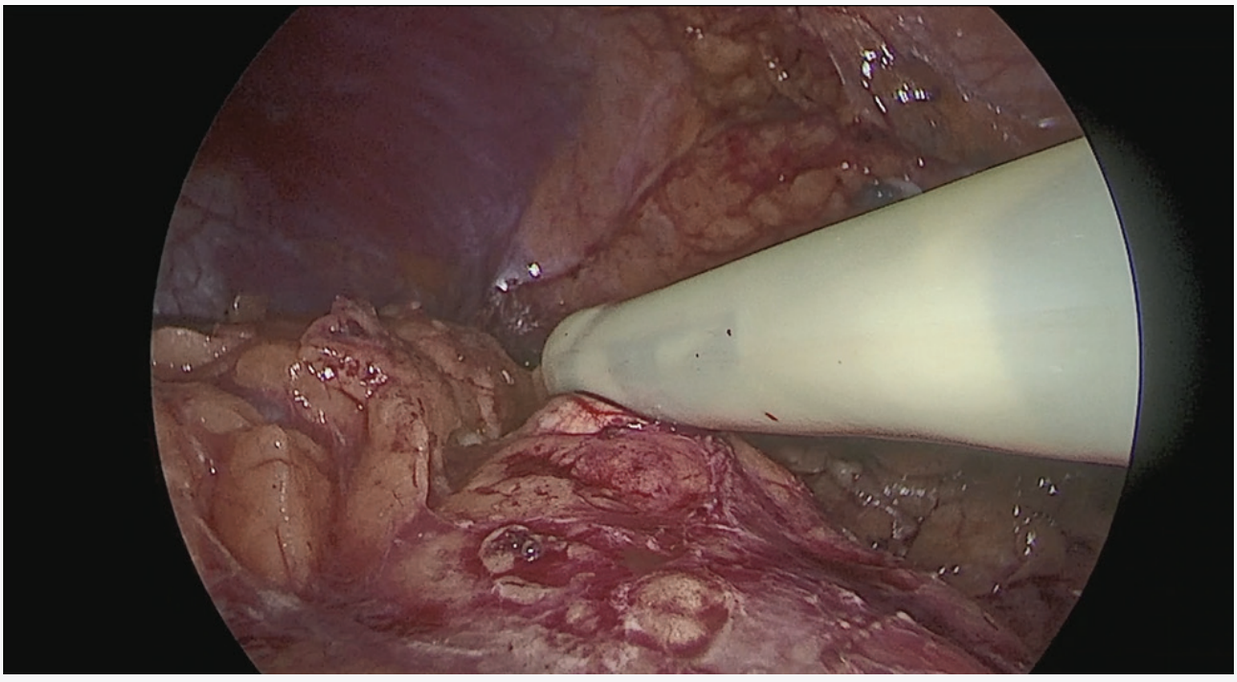

Figure 8. Intraoperative ultrasound

SURGICAL TECHNIQUE

6. HILAR OCCLUSION - MAIN ARTERY VS SUPER SELECTIVE CLAMPING

The anaesthesia team should be informed prior to arterial clamping. Intravenous administration of mannitol is not routinely practised. Arterial clamping can be done using laparoscopic bulldog clamps or laparoscopic Satinsky. For main artery clamping, two bulldog clamps can be considered with patient with larger artery or presence of atherosclerotic plaques. For super-selective clamping, NIRF with ICG can be considered to improve the outcomes.

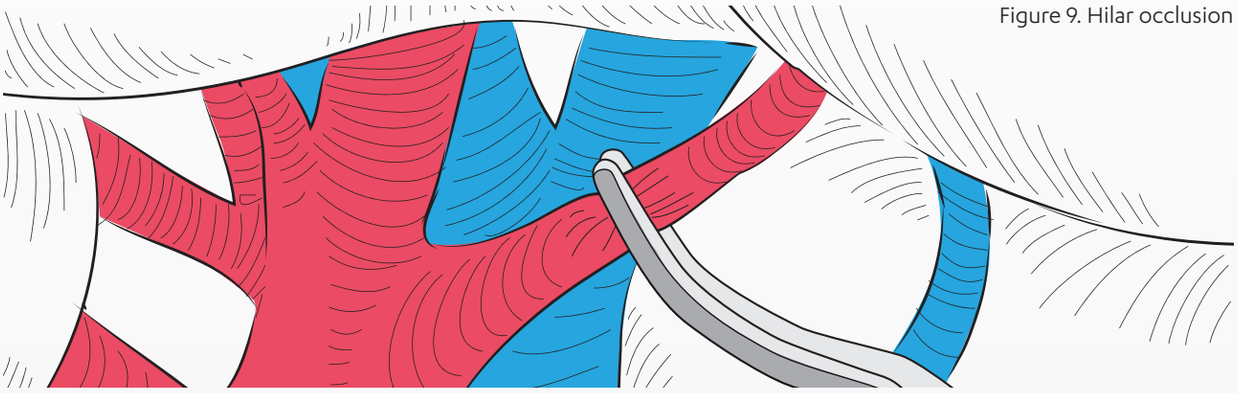

Figure 9. Hilar occlusion

7. USE OF NEAR-INFRARED FLUORESCENCE (NIRF) IMAGING WITH INDOCYANINE GREEN (ICG) FOR SUPER-SELECTIVE CLAMPING

After application of a bulldog clamp onto the tertiary branch, ICG is given intravenously at 0.3-0.5mg/kg. The duration of onset is rapid at 10-30 seconds. NIRF allows confirmation of zone of ischaemia before proceeding with tumour resection. In the event of failure to see an adequate zone of ischaemia potentially due to aberrant renal arteries, main arterial clamping can then be performed prior to tumour resection. This underpins the importance of preparing the hilum carefully.

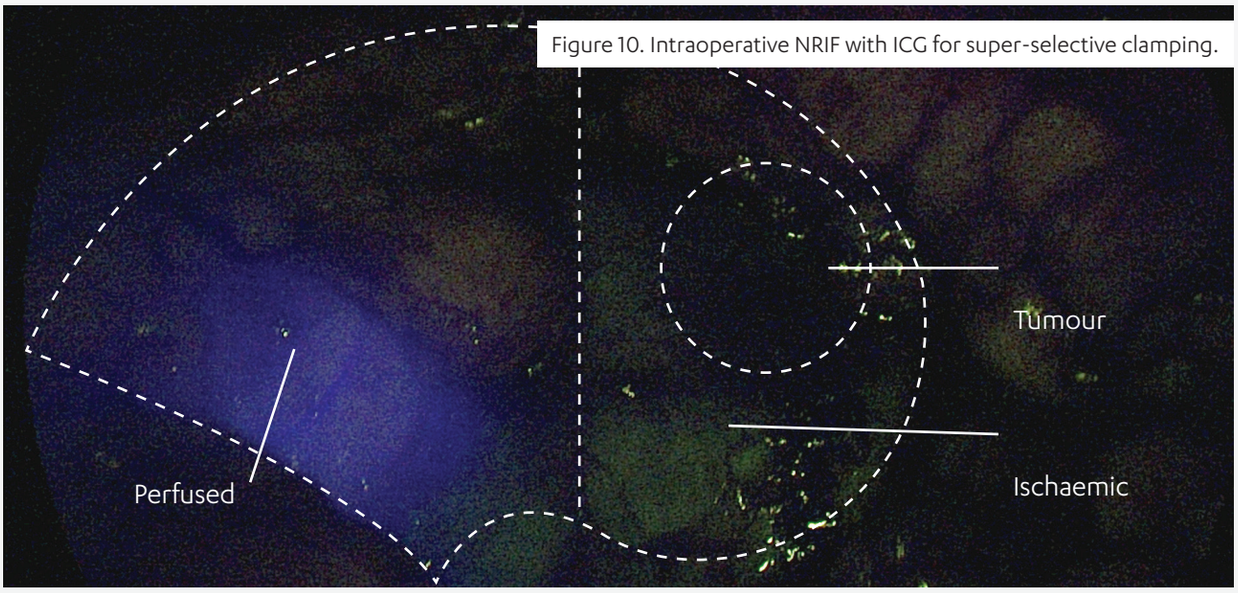

Figure 10. Intraoperative NRIF with ICG for super-selective clamping.

8. TUMOUR EXCISION

Two methods of tumour excision can be employed using cold scissors:

1. Conventional wedge resection with rim of renal parenchyma
2. Resection Enucleation Technique—i) start with conventional wedge resection until the pseudocapsule of renal tumour is identified; ii) after which blunt dissection along the avascular plane till resection is completed. iii) Any feeding vessels into tumour can be coagulated or clipped.

Other forms of tumour excision can be performed using energy device such as Harmonic® or hydrodissection.[14]

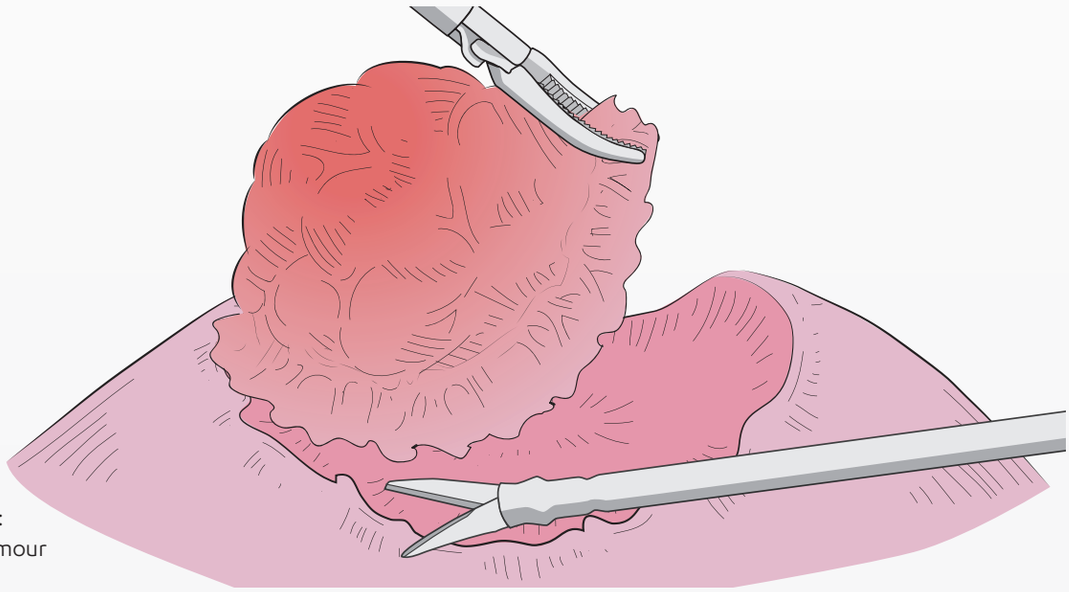

Figure 11a.
Tumour excision:
Conventional tumour excision

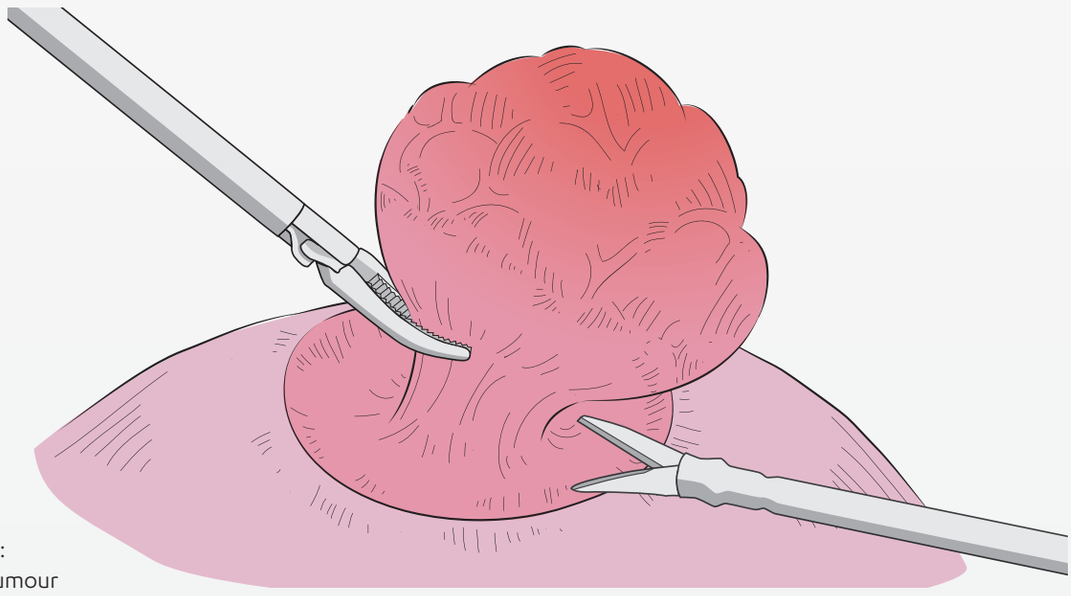

Figure 11b.
Tumour excision:
Enucleation of tumour

SURGICAL TECHNIQUE

9. RECONSTRUCTION AND RENORRHAPHY

Renorrhaphy starts with closure of deep layer of resection followed by outer layer closure of renal parenchyma with capsule. The deep layer is closed with StratafixTM 3/0 with Hem-o-lok® clip within the loop. The closure is done in a running fashion and any defect in collecting system is repaired using the same running suture. The outer layer closure is done using VicrylTM 1 suture with CT-1 needle. Interrupted closure is preferred as it allows for easier adjustment of tension and renders it less likely for the suture to cut through the renal parenchyma. Closure of both layers is performed using the sliding Hem-o-lok® technique.[15] Additional clips might be necessary to tighten the tension of renorrhaphy and prevent the slipping of existing clips.

Single layer closure can be considered in select cases by experienced surgeons. The deep layer of resection is closed with running suture omitting the closure of outer renal parenchyma and capsule. Recent systematic review has shown better renal functional outcome using the single layer closure technique.[16]

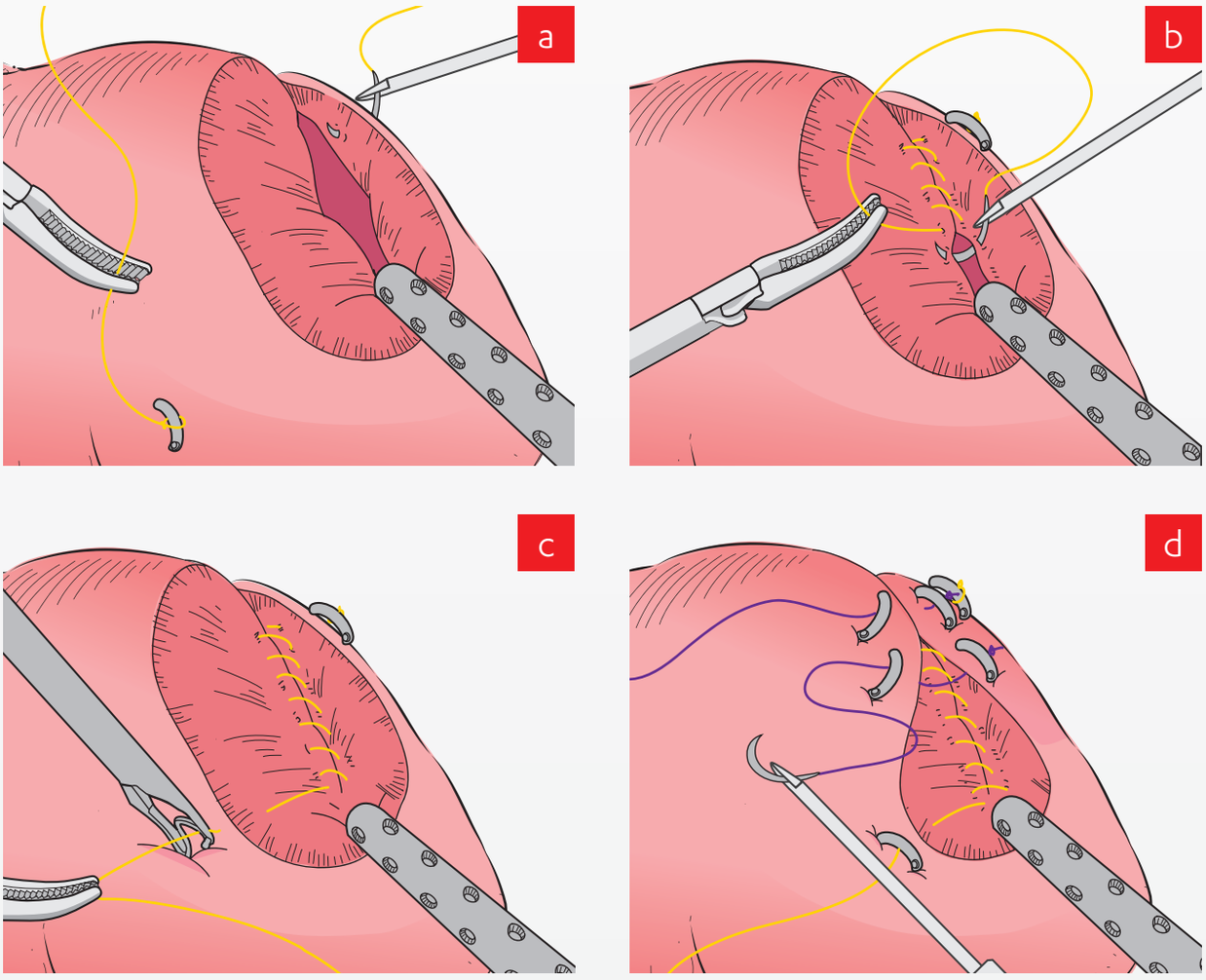

Figure 12. Reconstruction and Renorraphy: a, b and c: Inner layer closure using continuous Stratafix 3/0 with Hem-o-lok®, d: outer layer closure with interrupted Vicryl 1/0 with Hem-o-lok®

10. HILAR UNCLAMPING AND APPLICATION OF HAEMOSTATIC AGENTS

The Bulldog clamps are removed after completion of renorrhaphy. Early unclamping can be considered in select cases and has been shown to shorten warm ischemia time.[17] When considering early unclamping, the bulldogs can be removed after completion of the inner layer closure. The second layer closure is then carried out as previously described. After securing haemostasis, haemostatics can be applied to the resection bed. A combination of Evicel® and Surgicel SNoW™ is used and Gerota's fascia with perinephric fat is closed over the renorrhaphy.

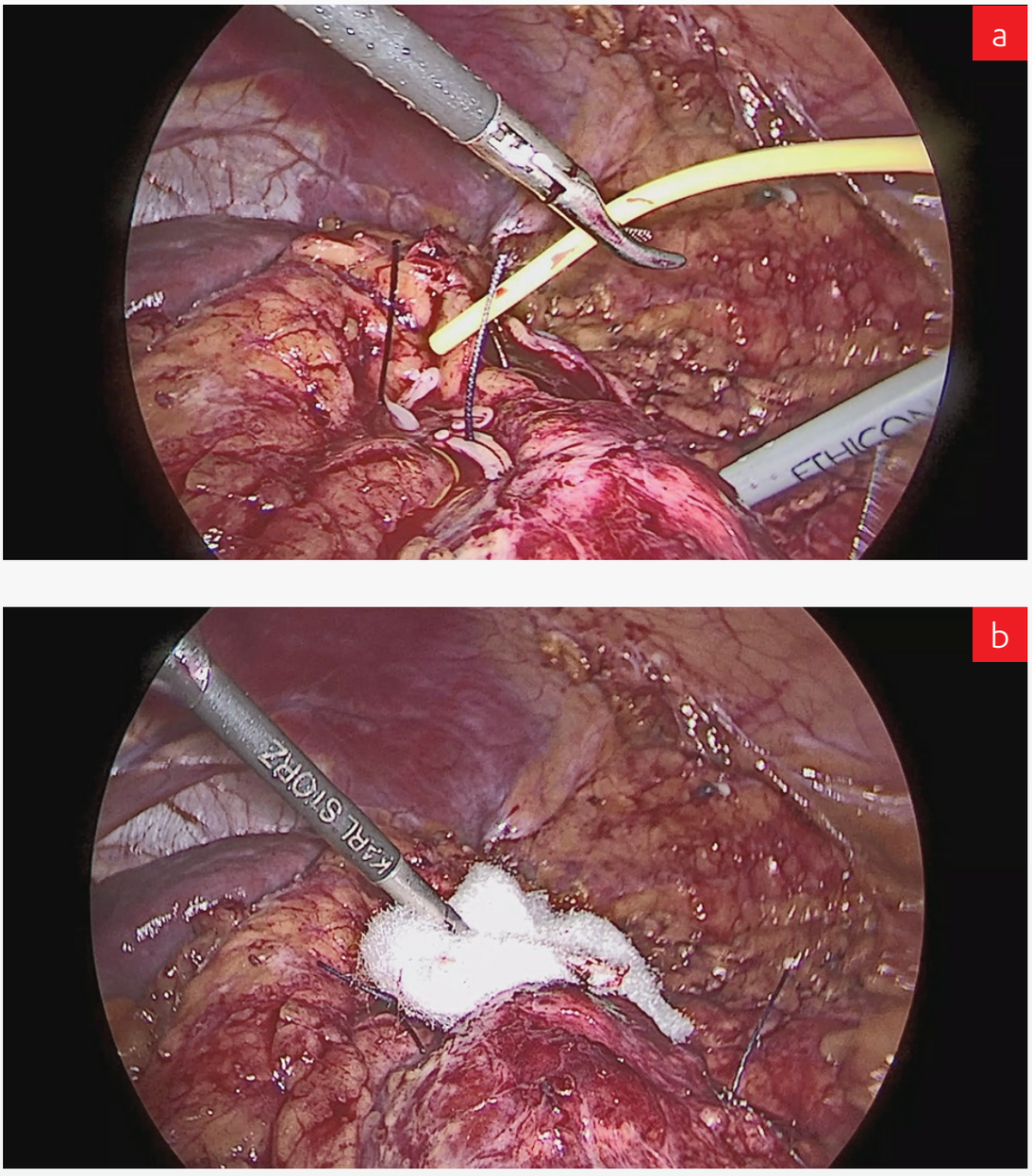

Figure 13. Application of hemostatic agents: a) Fibrin sealant, b) Oxidised regenerated cellulose

POST-OPERATIVE CARE AND COMPLICATIONS

POST-OPERATIVE CARE

Intravenous fluids and analgesics are given as per institutional protocol. Routine antibiotics are not required after the surgery. Renal panel and full blood count are monitored in the postoperative period. Foley catheter is removed the next day and patients are encouraged to ambulate with progression of diet. Drain is usually removed on postoperative day 1 and average hospital stay is 2 days.

COMPLICATIONS

Bleeding

Intraoperative bleeding is uncommon with careful planning, meticulous dissection and adequate exposure. Bleeding from the renal parenchyma is possible even after hilar clamping and is likely a result of inadequate clamping or an unidentified artery. This can be prevented with meticulous hilar dissection and minimised with aid of adjuncts such as NIRF with ICG. In case of inadequate clamping, additional bulldog can be applied or laparoscopic Satinsky can be considered.

Bleeding is common during hilar dissection. Mild bleeding can be controlled by direct pressure followed by cautery. Mild bleeding from renal vein is likely due to small tear and can be controlled using combination of mechanical pressure and increased pneumoperitoneum. Intracorporeal suturing might be required in cases of more severe bleeding. Additional ports can be inserted to allow assistant to provide suction. Bleeding from resection site after release of clamp is usually due to inadequate renorrhaphy. Direct pressure can be applied using a laparoscopic gauze with increased pneumoperitoneum while the renorrhaphy clips are tightened or reinforced. Open conversion should be considered if haemostasis is not satisfactory.

Post-operative close monitoring is important to help identify signs of bleeding. Blood transfusion is usually adequate for mild bleeding, however angioembolisation should be considered in patients presenting with delayed bleeding. This is usually due to pseudoaneurysm or arteriovenous fistula and usually presents as haematuria few weeks after surgery.

Urine leakage

Postoperative urine leakage should be suspected if there is elevated drain output with raised fluid creatinine level. A CT scan should be performed to determine presence of urinoma. Insertion of double J stent should be considered. Patient should be kept on antibiotics and any persistent urinoma should be percutaneously drained.

Bowel injury

Bowel injury can occur from trocar insertion or cautery injury during bowel mobilisation. All intraoperative injury should be repaired with on-table consultation with the general surgeon. During post-operative period, bowel injury should be suspected if there is fever, abdominal pain and distension, nausea and vomiting, leucocytosis, along with ileus and failure to progress feeds. A CT with contrast should be done and patient should be referred to general surgery if bowel injury is confirmed.

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AUTHOR'S NOTE

Minimally invasive partial nephrectomy has been shown to be superior over open surgery in terms of convalescence. The adoption of robotic partial nephrectomy in South East Asia remains limited due to cost-effectiveness and lack of robotic systems in most institutions. Therefore, laparoscopic partial nephrectomy represents a feasible and cost-effective alternative to robotic partial nephrectomy with excellent long-term oncological outcomes. However, it remains technically challenging with a steep learning curve and likely explains the under-utility of this technique.

We wanted to share our experience and technique of LPN and hope you find this guide useful. This book aims to give a comprehensive, step-by-step illustrated guide to Laparoscopic Partial Nephrectomy.

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