Laparoscopic nephrectomy simplified – A "two-window technique" for safer approach to hilum for a novice

Mallikarjuna Chiruvella, Ashwin Sunil Tamhankar*, Syed Mohammed Ghouse, Mohammed Taif Bendigeri, Purna Chandra Reddy Kondakindi, Deepak Ragoori

Department of Urology, Asian Institute of Nephrology and Urology, Hyderabad, Telangana, India
*E-mail: ashwintamhankar@gmail.com

ABSTRACT

Though the overall safety of laparoscopic nephrectomy (simple or radical) is well established, for a novice it remains a challenge. The classical description of laparoscopic nephrectomy entails dissection either from caudal to cephalad side or vice versa. Herein we describe our "two window technique" for managing renal hilum during laparoscopic (simple/radical) nephrectomy. Our main intention in description of this technique is to reduce the level of apprehension for a novice urologist for performing laparoscopic nephrectomy. After colon mobilization, sequential lower and upper windows are created around the hilum following which hilar vessels are dissected circumferentially when the hilum is at a stretch by traction from either of the window. There are multiple potential advantages of this method which includes easier and safer dissection especially for novice in this field by giving a safety window of application of vascular clamp in cases of vascular bleeds. Intrahilar dissection in stretched condition becomes safer with vision from all around 360^0 for safe application of Hem-o-lok® clips. Due to the widely exposed field, injuries to adrenal vein and lumbar veins would be minimized and the chances of missed accessory vessel would be minimized. En mass hilar control with vascular clamp in cases of partial nephrectomy is possible with same approach as well as the en block stapling is feasible in cases of nephrectomy. This needs a validation across multiple centers with comparative studies before considering it as a standard of practice. We sincerely believe that this is safe and easily reproducible by a novice.

INTRODUCTION

After the inception of laparoscopic approach for nephrectomy by Clayman *et al.* in 1991, the field of minimally invasive surgery has paved the way to higher advances.[1] In the last two decades, we have witnessed this growth which is not only limited to a single-port laparoscopic surgery but also includes natural orifice transluminal endoscopic surgery (NOTES), a true scarless approach for specimen retrieval.[2-4] Laparoscopic donor nephrectomy is the standard of care in majority of high-volume transplant centers. Although the overall safety of laparoscopic nephrectomy (simple or radical) is well established, for a novice, it remains a challenge. The most feared part in this surgery is the hilar dissection. Herein, we describe our "two-window technique" for managing renal hilum during laparoscopic (simple/radical) nephrectomy. Our main intention in description of this technique is to reduce the level of apprehension for a novice urologist for performing laparoscopic nephrectomy in a safer way.

STEP-BY-STEP DESCRIPTION OF LAPAROSCOPIC NEPHRECTOMY (SIMPLE/RADICAL) WITH "TWO-WINDOW TECHNIQUE"

Patient positioning

Once the patient is under general anesthesia, a catheter and a nasogastric tube are placed. The patient is placed in full 90° lateral position with the operative side up. The patient

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	DOI: 10.4103/iju.IJU_231_18

is positioned near the edge of the bed toward the surgeon to avoid any problems in instrument usage. The lower leg is placed straight and the upper leg is flexed at hip and knee joint and supported over a pillow placed between the two legs. Both the arms are flexed in the shoulder and elbow and supported over a flange, so that the final position of the arms is similar to fetal position. All pressure points are padded well including axillary roll to minimize brachial plexus injury. Large bolster is placed at the back to support the patient and then the patient is strapped to the table. Care is taken to ensure adequate chest expansion while placing a strap near the chest. Pneumatic calf pumps and body warmers are used.

Initial access and port placement

Pneumoperitoneum is created using a Veress needle, ensuring all safety precautions for insertion.[5] For pediatric cases, open access is preferred which also mandates suture fixation of the port to avoid dislodgment. Standard working pressure usually kept is 15 mmHg. Ports are placed in baseball diamond configuration to triangulate the working arms, keeping camera location at the level of hilum with due consideration to patient habitus. The external landmarks can be decided by analyzing the location of umbilicus with respect to hilum in computed tomography (CT). For right-sided nephrectomy, liver retraction port is placed as required. The entry point of the liver retraction port should be more cranial and toward the left side of the midline in thinner patients and whenever more dissection is expected near upper pole to lift the liver lobe more cranially. Another point to understand here is that extra 5 mm ports should be placed at liberty in laparoscopic nephrectomy in case one has some difficulty in maneuvering with existing ports to make the dissection easier and safer.[5]

Colon mobilization

After getting oriented to the inner anatomy, the first step of dissection starts with colonic mobilization. The plane between the colonic fat and Gerota's fat is the key plane for dissection. Initial incision is on the lateral side of colon where capillaries are seen running perpendicular to colon toward the lateral abdominal wall. The white line is the fusion of multiple fascial layers. The incision for colon drop is slightly medial to the white line toward the colon, keeping fatty tissue toward the colon. There are certain technical points to identify the correct plane. Mesocolonic plane easily rolls over the Gerota's fascia. If one is inside of either of the planes, this rolling movement will not be possible. Differentiation between mesocolonic fat and perinephric fat can also be made by color and compactness of the same. Colonic fat is bright yellow whereas perinephric fat is pale yellow [Figure 1a-CF,GF].[5] Colonic fat is more loosely packed whereas perinephric fat is densely packed inside the layer of Gerota's fascia which pops out instantaneously if we open the fascia inadvertently. Moreover, if one is in correct plane, the dissection usually is bloodless, requiring
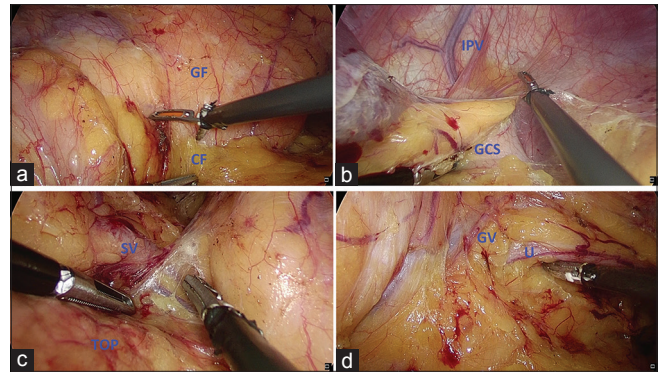

Figure 1: Left side laparoscopic nephrectomy steps. (a) Colon mobilization with separation of Gerotal fat from Colonic fat (GF, CF). (b) Dissection near superior pole in lienorenal ligament to visualize greater curvature of stomach and inferior phrenic vein (GCS, IPV). (c) Dissection and separation of splenic vessels and tail of pancreas (SV, TOP). (d) Lower window dissection on left side to lift ureterogonadal packet (U, GV)

minimal use of energy. The extent of colon mobilization on the caudal side is usually till the level of iliac vessels. On the right side, the incision of hepatic flexure reflexion is continued on the peritoneal reflection between kidney and liver parenchyma which proceeds from the lateral border of inferior vena cava (IVC) to parietal wall [Figure 2a]. If needed, liver retraction can be readjusted at this stage. This incision enables one to dissect through the adipose tissue by incising the Gerota's fascia to create a space above the right kidney. The colonic reflection on the right side exposes second the part of duodenum and lateral border of IVC. Standard kocherization is done to expose the lateral border of IVC which forms the landmark for further dissection [Figure 2b-IVC, D]. On the left side at the superior pole, the dissection goes till the level of diaphragm in sequential layers. In superficial plane, attachments of lienorenal ligaments are divided. After that, the plane between Gerota's fascia and splenic surface is identified to create a space between spleen and kidney, which extends further till one encounters greater curvature of stomach and diaphragm [Figure 1b-GCS]. Another landmark here is the inferior phrenic vein which runs along the diaphragm to merge into adrenal vein eventually [Figure 1b-IPV]. The tail of pancreas and splenic vessels is usually encountered in this maneuver, which are safeguarded [Figure 1c-TOP, SV]. Advantage of complete division in this lienorenal ligament is twofold: first is that the spleen is completely mobilized off the kidney and falls of medially without any retraction, and the second advantage is minimization of splenic injuries during further dissection.

Dissection in first window (lower)

After retraction of colon medially, the same plane is the guide for the ureterogonadal dissection just below the lower pole. On the right side, lateral border of IVC is the landmark for the gonadal vein identification which usually terminates in IVC just below the hilum [Figure 2c]. The flimsy layer of fascia near the great vessels can be reflected above or it
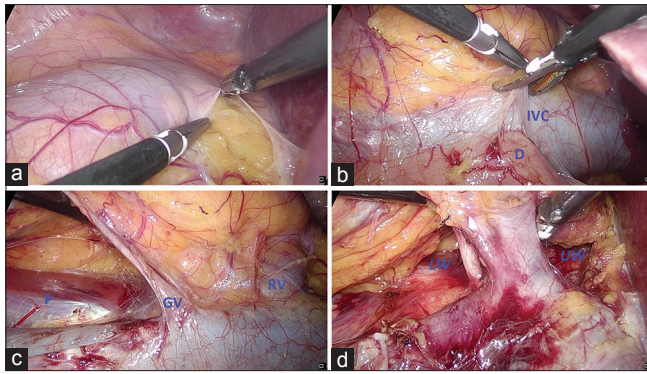
Figure 2: Right side laparoscopic nephrectomy steps. (a) Peritoneal fold incision between liver and kidney. (b) Kocherization with dissection along lateral border of inferior vena cava to medialize the duodenum (D, IVC). (c) Lifting of ureterogonadal packet to identify psoas muscle with renal vein above (RV, P, GV). (d) Completed dissection on both lower and upper windows (LW, UW)

Figure 3: Left side laparoscopic nephrectomy steps continued. (a) Dissection in lower window exposing lumbar vein draining into renal vein (LV, RV). (b) Incision of Gerota in the trough between adrenal gland and kidney in adrenal sparing dissection of upper window (A, K). (c) Dissection of upper window to expose adrenal vein draining into renal vein (AV, RV). (d) Clipped adrenal vein with completed dissection in upper pole (adrenal vein is usually spared unless it is too lateral to create a space lateral to it)

may be incised just lateral to the vessels if found thicker to identify the psoas muscle. For radical nephrectomy on the right side, the plane is created between gondal vein and IVC to identify psoas muscle [Figure 2c-GV, IVC, P]. For simple nephrectomy, gonadal vein is usually kept on IVC side and only the ureter is lifted to identify psoas sparing the gonadal vein. On the left side, as the gonadal vein drains into renal vein, ureterogonadal packet is lifted up for identifying psoas in cases of both radical and simple nephrectomy on the left side [Figure 1d-U, GV]. Another aspect to be noted here is to remember that ureter and gonadal cross near the lower pole so that gonadal vein is more lateral to ureter caudally. On the left side, as one approaches toward the hilum from the caudal side, small vessels are encountered which usually supply ureter from the aorta. These are the first group of structures encountered coming perpendicular to axis of large vessels after which one has to be careful for dissection as the hilum is just cranial to these perforators. More precise dissection in this area will delineate lumbar vein draining in posterior side of renal vein which can have a parallel or circumferential course with respect to renal artery after arising from the psoas muscle [Figure 3a-LV].[6] Lumbar vein is controlled with Hem-o-lok® clips before dividing, after which left renal artery is delineated much better.

Dissection in second window (upper)

After completion of lower window, before completing the hilar dissection, upper window is created. For adrenal sparing dissection, contour between superior pole of kidney and adrenal is identified and Gerota's fascia is incised in that trough [Figure 3b-A, K]. For adrenal excision along with nephrectomy whenever indicated, this plane shifts medial to adrenal gland similarly. Adrenal vein on the right side is usually much cranial to the hilum and need not be taken for creation of upper window. On the left side as the lienorenal ligament is already cut, adequate space already exists for dissection. As one approaches from lateral to medial side, first vascular structure to be encountered is adrenal vein on left side [Figure 3c-AV]. For clinical judgment, adrenal
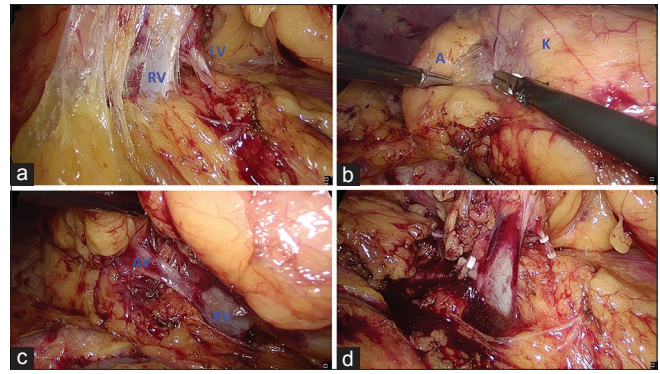
vein lies almost flush to aorta before it inserts into the left renal vein. Previously delineated insertion of left gonadal vein can be a rough guide for adrenal vein identification as adrenal vein inserts more proximally in renal vein than gonadal vein. Adrenal vein is clipped to create a window above it [Figure 3d]. If the adrenal vein seems more lateral, the plane can be created below the level of it for the upper window to identify psoas. Once the adrenal vein is clipped, fatty tissue on the cranial side of hilum becomes loose which makes dissection in that window easier. On both sides, adrenal sparing dissection mandates cranial traction on the adrenal with simultaneous counter traction on the upper pole of kidney which opens up the space to visualize feeders arising from the renal artery going to adrenal gland. These feeders are controlled with energy source to avoid minor bleeds and inadvertent attempts to control those which may potentially injure renal vascular structures prematurely as the hilar structures are flushed to this.

Hilar dissection

After both the windows are created till the level of psoas on both sides, hilum becomes prominent with subtle lateral traction on kidney tissue from either of the window [Figures 2d and 5a-UW, LW]. This makes intrahilar dissection easier. Also, accessory renal artery or early branching of renal artery can be identified as the complete hilum is exposed from both sides to give full 360° view [Figures 4a and 5b]. Blunt tip suction with low intermittent suction can be used for dissection around renal artery and vein so that the fatty tissue gets cleared, making the fibrous structures more prominent for dissection. The renal artery followed by vein is clipped and cut between the clips with all due consideration of safe application of Hem-o-lok® clips, keeping two clips on the sides of great vessels [Figures 4b and 5c].[7] It is always a good practice to occlude the vein proximally before actually clipping it to see for fullness beyond the level of occlusion in case
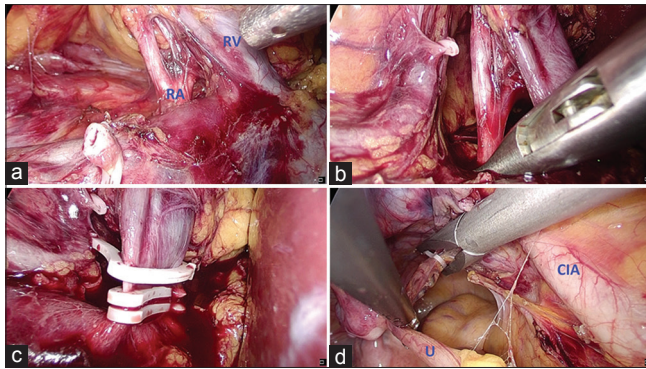
Figure 4: Right side laparoscopic nephrectomy steps continued. (a) Exposure and identification of early branching of renal artery behind the renal vein (RA, RV). (b) Clipping of renal artery. (c) Clipping of renal vein. (d) Clipping of ureter at the level of iliac vessels (U, CIA)

Figure 5: Left side laparoscopic nephrectomy steps continued. (a) Completed dissection of upper and lower window (UW, LW). (b) Circumferential dissection with delicate dissection between renal vein and artery. (c) Clipping of renal artery. (d) Clipping of renal vein

of doubtful second artery after controlling the main renal artery [Figures 4c and 5d]. Care is taken to bare the vessels completely by controlling lymphatics with the use of energy. Full circumferential mobilization of vessels is mandatory before clipping.

Ureter clipping and specimen extraction

Ureter is clipped at the level of iliac crossing and kidney is separated from the lateral attachments. Specimen is bagged and extracted from the muscle splitting modified Gibson's incision [Figure 4d-U, CIA]. Hemostasis is ensured after lowering the intra-abdominal pressure. Drain is placed as per the surgeons' preference.

DISCUSSION

Although a laparoscopic nephrectomy is the standard of care, there is a learning curve described in literature of around 15–50 cases.[8,9] The potential complications, especially vascular complications, are the major reasons for open conversion.[10] These vascular injuries leading to open conversions sometimes can be a nightmare in emergency setting, especially in living donor nephrectomy, which in fact is the most common cause for open conversion for laparoscopic nephrectomy.[10] For venturing into the field of laparoscopic nephrectomy, most difficult part from the perspective of novice is the hilar dissection. Till date, there are different methods described for nephrectomy, but the major limitations which we perceive is that the precise method for safe hilar dissection is not classically elaborated.[5,11] Majority of descriptions mention that the dissections proceed either from caudal to cephalad or the reverse manner.[5] We believe that our described approach for the laparoscopic nephrectomy, be it a simple or radical, is safe and reproducible. In our opinion, there are multiple advantages of our method for the ease of completing the procedure, especially from the perspective of novice.

First and foremost, before one approaches actual hilum, the dissection is completed on both sides to create the windows.
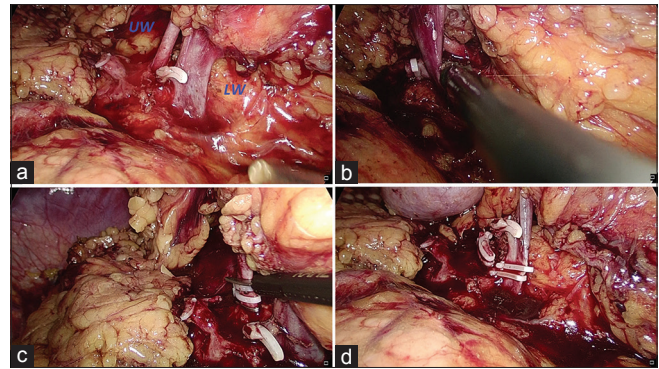
In the learning process of this procedure, if there are any major vascular hilar bleeds, as the hilum is already dissected all around, a soft vascular clamp or Satinsky can be applied immediately to avoid any excessive blood loss. Even as a temporizing measure, one can hold the hilum with the grasper with ratchet in case of hilar bleed. This either may benefit in terms of avoiding the open conversion by tackling the injury with some intervention by an expert or may minimize the potential complications because of excessive hemorrhage in case of decision for open conversion. Another advantage is that for the dissection of renal artery, which is usually located posterior to the vein, one can have the opportunity to complete the dissection from either of the two windows. We believe that the skeletonization of vessels is much better if one proceeds from both sides to complete the dissection. For the safe application of Hem-o-lok® clip, mandatory step is to dissect the vessel completely all around to remove all the fibrofatty tissue before application of a clip.[7] In the routine approach which is described for the nephrectomy, which usually proceeds in one direction, the potential advantage of dissection from the other side or even confirmation of complete dissection before application of clip is compromised. This may have some adverse implications as the dissection from one side is similar to working in a narrow hole, rather than exposing the field completely. Similarly, for the safe of applications of Hem-o-lok® clips, it is recommended to keep a length of around 3 mm before the first clip on body side with stump of approximately 2 mm distal to the last clip.[10] This in fact is true for all the vascular structures which are controlled by clips including renal, gonadal, and vertebral veins. Once the hilum is under the stretch after dissecting both the windows, sufficient length is gained for safe clipping and cutting of pedicle. The same is valid for clipping of gonadal, adrenal, and lumbar veins as one has the completely dissected window on either side of hilum before clipping these veins.

During our approach, as the dissection proceeds from both sides to narrow down the contents before actually doing intrahilar dissection, chances of missed accessory vessel

are minimized. This minimizes the inadvertent bleeding or engorgement of graft after clipping renal vein. It is customary to evaluate renal vein by compressing it with blunt grasper after clipping main renal artery.[5] But in that case, confusion and attempts of identification of second missed artery may lead to probable complications in the hands of a learner. As the conventional imaging may not be as reliable as CT angiography or magnetic resonance imaging angiography for preoperative evaluation of accessory arteries, our approach may be prudent in regular practice.[10,12] The incidence of either accessory artery or early branching is almost to the extent of 30%.[13] With our approach, in these one-third of cases, clipping of renal vein after clipping the main renal artery would be much safer as the dissection is almost narrowed down to the extent that kidney is almost attached only by hilum medially at the time of clipping the major vessels. Adrenal vein bleed is a potentially life-threatening complication and probable reason for open conversion during laparoscopic nephrectomy. For the evaluation of learning curve, analysis of 150 cases of laparoscopic nephrectomy had four renal artery injuries requiring open conversion.[9] In the same series, there were five renal vein injuries and three adrenal vein injuries.[9] Adrenal vein injury is another nightmare to tackle which may be easier if we dissect the upper window right in the beginning by directly approaching the adrenal vein of the left side.[9,10] The dissection of the lower window to delineate the gonadal vein insertion before the upper window guides for probable insertion site of adrenal vein in the left-sided nephrectomy. Hence, this stepwise two-window approach minimizes these potential complications.

Most dreaded complication which has worst outcomes in the left-sided nephrectomy is the ligation or injury to of superior mesenteric artery.[10] The usual outcome if not revascularized early with graft is bowel ischemia with resultant death.[10,14] We believe that these injuries occur as a combination of two situations, kidney not being mobilized away from the great vessels during dissection with an attempt of clipping in cases of inadvertent hilar bleed. In our approach, after creation of both the windows, upward traction of kidney by a working instrument in any of the windows brings the hilum in traction which stands out away from the aorta. This minimizes potential application of clip on the anterior surface of aorta to avoid this life-threatening complication. Subtle lateral stretch before clipping the vessels may avoid this complication.

Although we are not proponents of *en bloc* vascular stapling of hilum, a randomized controlled trial comparing *en bloc* versus individual stapling showed comparable outcomes without any long-term complications in terms of fistula formation on clinical and radiological follow-up.[15] In centers wherein the *en bloc* stapling with Endo GIA® stapler is a routine practice, the double-window technique would be the easiest approach to proceed with the nephrectomy. This approach also gives
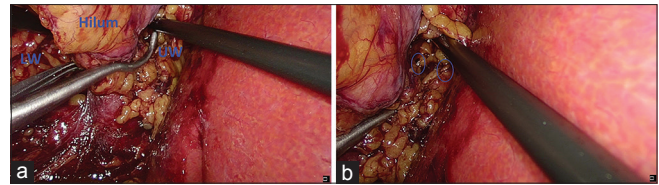

Figure 6: Two-window technique for application of Satinsky clamp across hilum in cases of laparoscopic partial nephrectomy. (a) Satinsky clamp across hilum with adequate exposure in both the lower and upper window (LW, UW). (b) Safe application of clamp to visualize both the arms before final application

advantage during laparoscopic partial nephrectomy wherein Satinsky clamp is applied to control the hilum *en masse*.[16] As this procedure does not mandate intrahilar dissection, the adequately created windows on both sides give opportunity for safe control of hilum by enabling visualization of both the limbs of clamp across the hilum [Figure 6a and b].

There have been attempts for simulation of vascular injuries and management of those in simulators for the trainees in laparoscopic nephrectomy, which may not be feasible in every center.[17] We sincerely believe that this approach would give more comfort for trainees and learners in this field. We admit our limitation as the need for validation of this technique across multiple centers and prospective comparative studies before it is considered as a standard of practice. We consider the following points as the potential advantages of our "two-window technique."

1. Hilar vascular bleeds during dissection can easily be controlled by the application of vascular clamp or grasping forceps
2. Intrahilar dissection becomes easier and safer with advantage of dissection in a relatively stretched hilum with a possible vision from both sides as per the requirement
3. Accessory renal artery or early branching can be identified before clipping the main renal artery as the dissection proceeds from both sides to narrow the renal attachments only to the hilum
4. Adrenal vein or lumbar vein bleeds can be easily controlled due to adequate exposure leading to minimization of open conversion
5. Easier for a novice in this field to complete the procedure
6. *En bloc* stapling can be easily possible for the centers which believe in *en bloc* vascular stapling
7. *En masse* clamping of hilum with Satinsky or vascular clamp during laparoscopic partial nephrectomy is possible without actual intrahilar dissection.

CONCLUSION

The "two-window technique" for laparoscopic nephrectomy (simple/radical) is safe and easily reproducible, especially for a novice with a potential for minimization and/or easy salvage of vascular complications which may lead to life-threatening hemorrhage.

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