Laparoscopic and Robot-Assisted Nephrectomy

22

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Tips, Tricks and Pitfalls

- Examine carefully the position of the donor preoperatively, to avoid discomfort for the patient and for the surgeons.
- Communicate with all the members of the surgical team, including anaesthesiologists and nurses, to clarify the main phases of the operation.
- Get ready for a rapid open conversion, drawing on the body of the donor the midline incision.
- Remind that hand-assisted technique can become useful to manage unexpected difficulties.
- Avoid the use of non-tissue affixing ligation technique for renal vessels.
- Plan a strategy to maximize the length of renal vessels, using Endoscopic GIA or TA stapling device, keeping away from early bifurcations.
- Note the advantages of using a Ligasure™ vessel sealing for dissection, to shorten operative time and to avoid clips interfering with the stapling suture line.
- Pay a lot of attention to haemostasis of the Pfannenstiel incision, since the heparin bolus effect may result in subcutaneous hematoma.

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The scientific community has largely demonstrated that living donor kidney transplantation (LDKT) is a valid alternative for patients with end-stage renal disease (ESRD). When considering long-term patient and graft survival, the results of LDKT are significantly better than the ones obtained with deceased kidney transplantation [1, 2]. Moreover, LDKT offers several advantages when compared to deceased kidney donations as the recipient experiences better quality of life and better immediate graft outcome. Moreover, LDKT offers the possibility of transplanting patients either pre-emptively or after a shorter dialysis period.

Over the last decade, the United Network for Organ Sharing (UNOS) has reported that LDKT is performed more and more frequently, so as to

P. Aseni et al. (eds.), *Multiorgan Procurement for Transplantation: A Guide to Surgical Technique and Management*, DOI 10.1007/978-3-319-28416-3_22

exceed the number of transplantation with deceased donors. The reasons for fostering the living kidney donations may depend on the demonstrated advantages of the LDKT when compared to deceased donor transplantations as well as on the diffusion of minimally invasive surgical procedures for kidney harvesting. Minimally invasive techniques appear to be more acceptable for the donors, most likely because of the significant reduction in postoperative pain, decreased length of hospital stay, rapid patient rehabilitation and better cosmetic results. Because of that, the laparoscopic approach for living donation nephrectomy, first reported by Ratner in 1995 [3], has been performed in increasing number of cases, both for hand-assisted and for totally laparoscopic procedure.

22.1 Preoperative Evaluation and Intraoperative Management of Living Donor

Besides the nephrological and psychosocial evaluations, which have to be made in accordance with the clinical practice guidelines, the study of the surgical and anaesthesiologic risk of the living donor has to be cautiously considered, allowing for only those subjects ASA Class I or II (American Association of Anaesthesiologists Physical Status Classification) to become donors.

Moreover, as with the open procurement procedure, preoperative considerations of anatomy and functional status of the donor kidneys are crucial for the side of the nephrectomy procedure. It is mandatory to clarify whether one kidney has a lower function (through a nuclear scan with split renal function), abnormalities of the parenchyma (cysts, angiomyolipoma, ptosis) or of the urinary tract (lithiasis, ureteral duplicity, pyelectasis) through ultrasound and urographic exams or vascular abnormalities (multiple renal arteries, circumaortic or retroaortic renal veins) through three-dimensional spiral CT or magnetic resonance angiography.

The kidney with worse or imperfect features will be harvested, although in case of absence of significant abnormalities, generally the left kidney is preferentially used, because of the anatomically longer renal vein at this side.

The contraindications to laparoscopic donor nephrectomy are the same as those established for open nephrectomy, although a previous abdominal surgery may increase the complexity of the procedure through a transperitoneal approach. Nevertheless, overweight or slightly obese subjects should preferentially undergo laparoscopic procedures, because of the minor risk of wound complications, better postoperative respiratory performance and early mobilization [4, 5].

Donors are at moderate risk of developing venous thromboembolism and should receive prophylactic low-molecular-weight heparin (starting before surgery and continuing for at least 5 days or until discharge), supplemented with graduated stockings and/or intermittent pneumatic compression devices. Since pneumoperitoneum increases intra-abdominal pressure, causing a decrease in renal blood flow and glomerular filtration rate resulting in oliguria, administration of IV fluids the night before surgery may be useful.

Fasting before operation and induction of anaesthesia lead to relative hypovolemia and the goal is to compensate this before pneumoperitoneum is started. To counterbalance the increased intra-abdominal pressure, vigorous IV hydration during laparoscopic donor nephrectomy is nowadays recommended in an attempt to optimize preload and promote diuresis [5]. The adequacy of intravascular volume expansion can be monitored by the turgor of the renal vein; a collapsed renal vein signals the need for more liberal use of intravenous fluids. A brisk diuresis is stimulated throughout the procedure by an 80 mL bolus administration of mannitol. Just before removing the kidney, the donor is given 20 mg of furosemide and 5000 UI of heparin. When the kidney has been removed, protamine is generally given to reverse completely the anticoagulant effect of heparin. Moreover, the role of the anaesthesiologist is to obtain a sufficient laparoscopic working space; therefore the patient must be kept completely relaxed.

In the postoperative analgesia, non-steroidal anti-inflammatory drugs (NSAIDs) are generally

avoided because of their potential nephrotoxicity; intravenous analgesia (paracetamol) is limited to the first postoperative day, and patients should be converted to oral analgesic when clear liquids are introduced on the second postoperative day. Special attention should be paid to the prevention of complications related to lateral position (nerve damage, airway compromise, pressure sores, venous access compromise).

22.2 Laparoscopic Living Donor Nephrectomy: Operative Procedure

Before proceeding with the positioning of the patient, it is useful and recommended to mark with a dermographic pen the midline, the suprapubic Pfannenstiel line and the standard position of the trocars. The line marks will become very helpful in case of need of a rapid open conversion or, more frequently, to achieve a better cosmetic result for the Pfannenstiel incision, which is made when the rotation of the patient may lead to a distorted incision (Fig. 22.1). The marks for the trocar introduction are particularly convenient for patients with global abdominal enlargement.

The positioning of the patient is a modified lateral decubitus position, with the hips rotated back and the arms extended above the head (Fig. 22.2). The table is only slightly flexed, to expand the area between the costal margin and the pelvis. It is important to make sure that the sternal support of the surgical table is placed cranially enough in order to not interfere with the actions of the hand of the first operator. The arm of the patient lays over the contralateral, and no supports are needed, since they could hamper free movements of the surgeon. A 12 mmHg pneumoperitoneum is established with the Hasson open technique. Instead of the traditional periumbilical incision, a 2 cm paramedian incision slightly above the umbilicus (between the umbilicus and the Palmer's point) can lead to some advantages, because it is a safe incision with no muscle cutting, with low risk of incisional hernia. The fascia is incised and the peritoneum is grasped and opened. Care is taken to ensure that there is no bowel attached. Two stay sutures are placed in the fascia around the opening to secure the Hasson cannula that is placed into the peritoneal cavity in order to avoid leakage of the CO_2 gas used for insufflation. We consider safer and recommend the open approach, although the Cochrane Database of Systematic Reviews 2012 concluded that the open entry technique is associated with a significant reduction of failed entry (compared to the closed entry technique), with no difference in the incidence of visceral or vascular injury [6]. The videoendoscope is inserted in this first port, and three more operative ports are placed: a 12 mm in the iliac fossa on the middle clavicular line (between the umbilicus and the anterior superior iliac spine), a 5 mm in the hypochondrium on the middle clavicular line (two fingerbreadths below the costal margin) and a fourth 5 mm trocar for the assistant in the flank (Fig. 22.3). As far as the left sided procedure is concerned, after the exploration of the abdominal cavity, the ascending and sigmoid colon are taken down starting from the splenic flexure by dividing the lateral attachments with DeBakey graspers and curved scissors. The colon is reflected medially with exposition of the Gerota's fascia. The dissection can subsequently be accomplished bluntly, reducing the risk of

Fig. 22.1 Midline, suprapubic line marks and position of the trocars

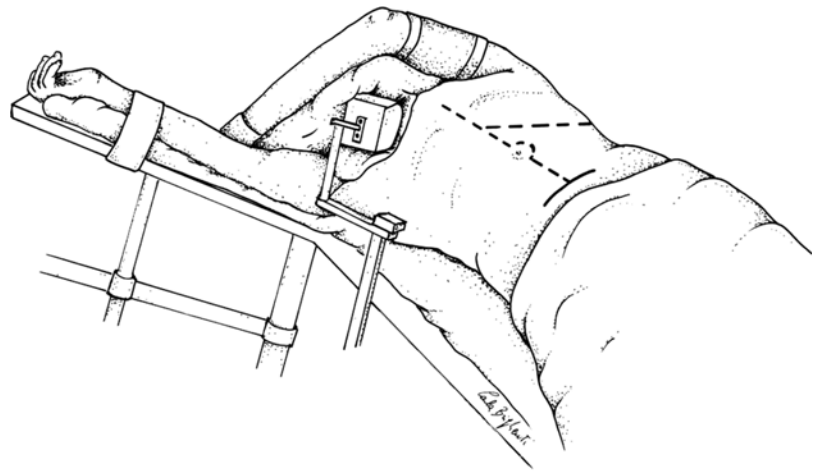

Fig. 22.2 Modified lateral decubitus position

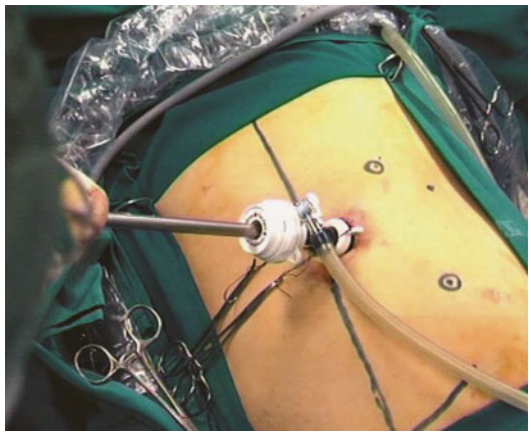

Fig. 22.3 Introduction of the laparoscope and sites of operative trocars

buttonholing the mesocolon, sweeping the tissue medially and developing a natural plane between the mesocolon and Gerota's fascia. Once the colonic mobilization has been completed, the left ureter and gonadic vessels are easily identified. The next step is full mobilization of the ureter and the gonadic vessels, which will be separated from the surrounding structures but not divided. By tracing the gonadal vein in a cephalad direction, the renal vein is exposed. Through the fourth port, a retractor is manoeuvred by the third operator gently pushing the tail of the pancreas away from the upper margin of the renal vein. The renal vein has to be cleared completely of the surrounding tissue, and the adrenal, gonadal and lumbar branches are cut. The first branch to be cut is the adrenal vein, which is kept in light traction by the integrity of the gonadal vein. The use of a bipolar, vessel-sealing device (Ligasure™) instead of clips-and-cuts allows to shorten the operative time and avoids the presence of clips in the stapling suture line of the renal vein, but it seals vessels less than 7 mm in diameter; therefore it cannot be used for hypertrophic branches. The first operator can introduce the device through the flank port in order to obtain an optimal direction for reaching the adrenal vein (Fig. 22.4).

The gonadal vein can be easily divided with the same device through the hypochondrium 5 mm port, whereas much attention needs to be paid for the dissection and division of the lumbar vein, which is often short and with early bifurcations. To expose the lumbar vein, it is necessary to elevate and pull towards the hilum the lower pole of the kidney with DeBakey grasper, in order to proceed with its ligation (Fig. 22.5).

The renal artery, which lies posterior to the vein, can be exposed through such elevation of the lower pole of the kidney and has to be separated from the surrounding nervous plexus at the level of its origin form the aorta. To complete the dissection, the adrenal gland is separated from the upper pole of the kidney, using Ligasure™ device, to avoid bleeding from the small arterial adrenal

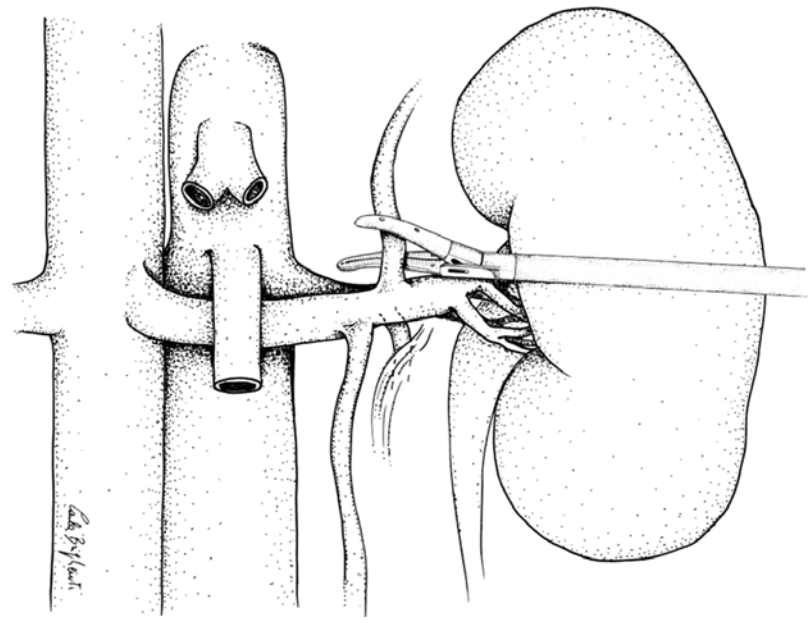

Fig. 22.4 Section of the left adrenal vein by a Ligasure™ device inserted through the flank 5 mm port

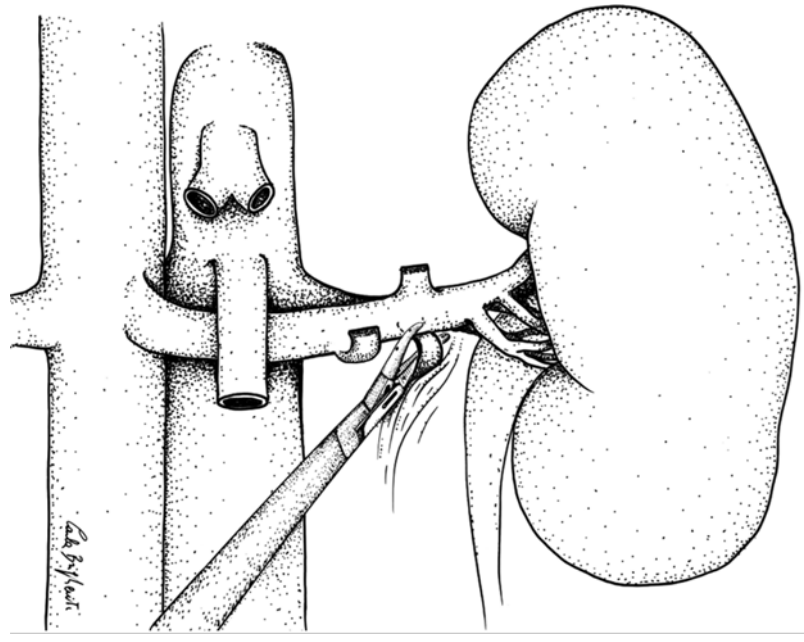

Fig. 22.5 Ligation of the lumbar branch by Ligasure™ device

branches and to obtain an effective synthesis of the lymphatic tissue on the cephalic side of the renal artery, otherwise causing lymphatic extravasation and chyloperitoneum. Once the main renal vessels are fully dissected, the procedure continues with full mobilization of the kidney from the Gerota's fascia starting from the lower pole upward, along the lateral surface of the kidney, completely mobilizing the kidney except for the renal pedicle. The gonadal vein, ureter and mesoureter are then separated from the psoas muscle and dissected free, and the ureter is cut. A flow of urine is expected to

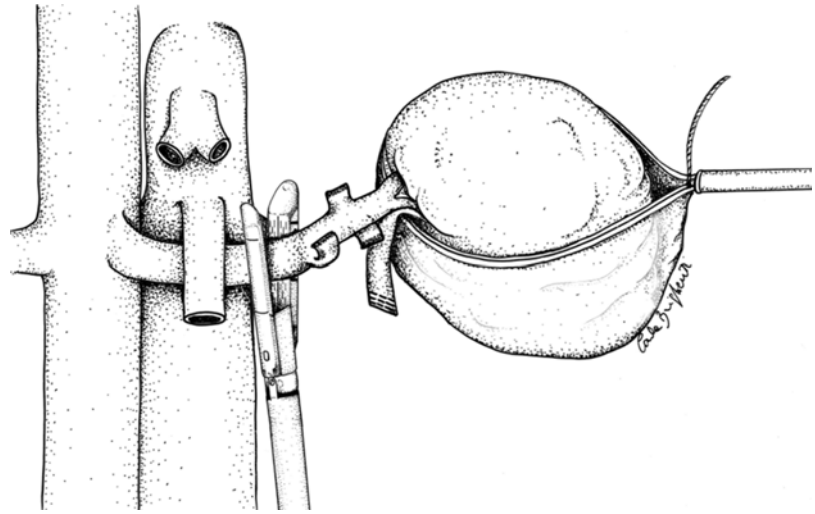

Fig. 22.6 Kidney loaded into the Endobag and Endo GIA stapler division of the renal vein

be seen from the ureter, demonstrating a good perfusion of the kidney during the procedure. In case such flow should not be observed, a 10–15 minutes resting with interruption of the pneumoperitoneum is advisable.

At this point of the surgical procedure, the 7 cm Pfannenstiel incision just above the pubis is made, and the Endo Catch™, a retriever pouch device, is introduced. To ensure the persistence of pneumoperitoneum without leak of gas, a pure string using size 0 monofilament suture is placed to surround the device's entry, and some wet lap sponges are positioned around. The kidney is loaded in the bag and then lifted with some stretching of the renal vessels, heparin 5000 UI is administered and a vascular endoscopic GIA stapler is used to divide the renal artery followed by the vein (Fig. 22.6). It is necessary to retain that using a non-tissue affixing ligation technique is no longer acceptable and that hem-o-lock® ligation system is contraindicated for ligation of the renal artery during laparoscopic nephrectomy by a FDA recall since 2006 [7].

The kidney, fully loaded inside the endobag, is removed through the Pfannenstiel incision, and protamine is usually given to reverse completely the anticoagulant effect of heparin.

For right-sided procedures, port placement is a mirror image of that used for the left-sided procedure as well as the other surgical steps; the main variations of the technique are aimed to preserve maximal renal vein length. After the institution of pneumoperitoneum and the exploration of the abdominal cavity, the cecum is mobilized and reflected medially, the liver is lifted away from the upper pole of the kidney using a retractor through the fourth flank port. Isolation of the ureter and gonadal vein does not differ from that described for the left-sided procedure. The gonadal vein can be divided from the vena cava between clips, far enough from the renal vein, without troubling the stapler section of the main vessels. Usually no branches of the renal vein are present, although much attention has to be paid to lumbar veins originating from the inferior vena cava, during the isolation of the renal artery. Separation of the adrenal gland can be obtained by Ligasure™ device, as in the left-sided procedure, allowing the isolation of the upper margin of the renal vein. Aiming to maximize the length of the renal vein, the introduction of a hand port at the level of the Pfannenstiel incision would allow the kidney to be lifted on its pedicle under stretch, before the division of the vessels. Moreover, in case of early artery bifurcation, the hand port would allow to mobilize the kidney medially, facilitating the full control of the artery proximally to its origin.

The division of the renal vein has to be performed in a plane parallel to the inferior vena cava, introducing the endoscopic GIA device into the right lower quadrant port. The skill of Endo GIA to articulate allows achieving such parallel plane (Fig. 22.7a, b).

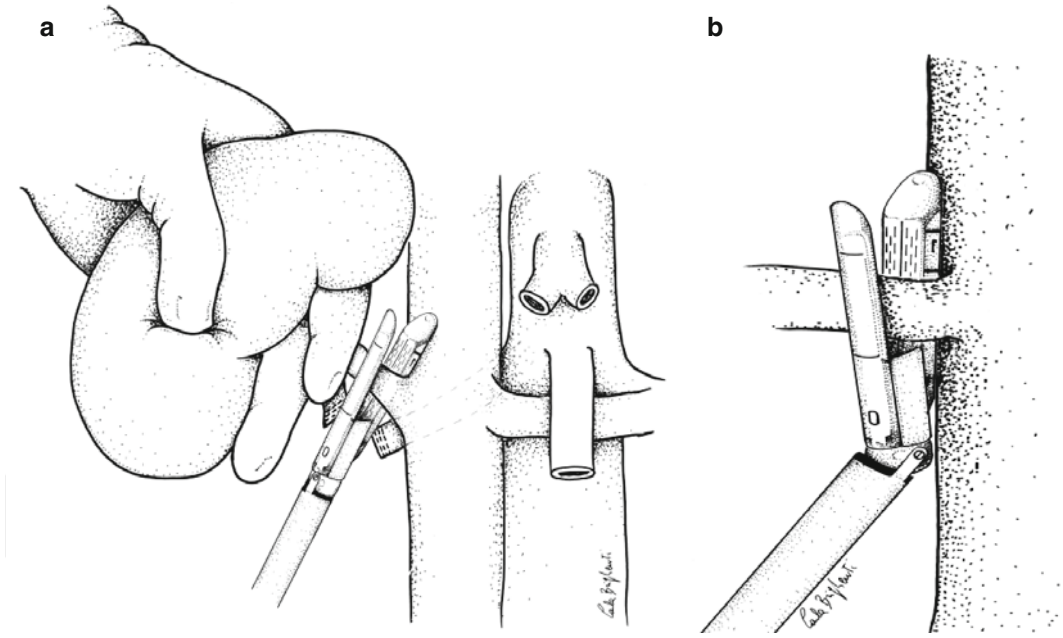

Fig. 22.7 Insertion (**a**) and appropriate direction parallel to the inferior vena cava (**b**) can be obtained with the articulating Endo GIA

Considering that such device results in the loss of approximately 1–1.5 cm of length of renal vein, the use of an Endo-TA can be planned. Nevertheless, with this device, no articulation is possible; therefore a decision has to be taken in choosing between the advantage of sparing few millimetres of the vein length with the TA stapler or optimizing the direction of the suture line, based on the anatomical situation during surgery.

The peritoneum and the fascia of the Pfannenstiel incision are closed with absorbable sutures. The operative field is checked for bleeding and a drain is left in place; the 12 mm port site has to be verified to make sure that no lesions of the epigastric vessels are present, and no suture is needed if bladeless trocars are used, otherwise a figure-of-eight absorbable suture aided by the Carter-Thomas instrument is recommended.

The technique described is essentially a pure laparoscopic approach, although the availability of a hand-assisted device should always be equipped, not only in the right side nephrectomy, to better attain the length of the vessels, but also in the left-sided procedures. As a matter of fact, in case of a lack of gas pressure of the pneumoperitoneum after the Pfannenstiel incision, or to retract the colon for some moderately obese patients, or finally to handle some complications, the introduction of the operator hand may prevent the need for open conversion. Although the hand-assisted technique is an available option, in our experience, pure laparoscopic approach is feasible for both left and right nephrectomies [8].

22.3 Robotic-Assisted Technique for Kidney Living Donation

Tips, Tricks and Pitfalls

- Do not put metallic clips where you will need to use staplers.
- Place the patient in order to avoid collisions among robotic arms and between robotic arms and the patient itself.
- For donor safety concerning renal artery:
  - It's better to use TA instead of GIA stapler to avoid the risk of stapler malfunctioning.

  - The section should be done with robotic scissors after placement of an hem-o-lock on the arterial stump.
- Always administer one bolus of curare together with heparin to facilitate the kidney extraction.

Left Nephrectomy

- Extend the dissection of the splenopancreatic block up to the left diaphragmatic crura.
- Renal vein should be encircled with an elastic tape after the section of gonadic and adrenal veins in order to:
  - Easily recognize it during posterior isolation of the kidney
  - Modulate robotic arm's strength with adequate traction during dissection manoeuvres and staplering.

In 2002 Horgan S. et al. described the first series of robotic-assisted nephrectomy (RAN) for living donor kidney transplantation [9]. Since then, few reports described this procedure with various changes of the surgical technique [10–15]. No matter how the different techniques adopted for this procedure, all articles confirmed the safety and feasibility of the RAN [16–19].

Robotic-assisted surgery is often replacing traditional surgery because it seems to offer clear advantages when compared to traditional laparoscopy. Robotic assistance provides various comforts to the surgeon, such as 3D stable view of the operative field, endowrist instruments that are easy to use and the possibility to reduce the postural fatigue which is very common among surgeons performing laparoscopy. Those comforts play an important role in a successful outcome of the surgical procedures [20]. As a result, robotic instruments allow the surgeon to replicate movements of the traditional open technique in a minimally invasive environment. Knots and sutures, for instance, can be very easily performed using the robot while they represent a crucial issue in the traditional laparoscopy. All these factors represent a valuable advantage when compared to the long and complex laparoscopic surgical operations which induce mental and physical stress and may well lead to a progressive decrease of the surgeon's lucidity and concentration. The simplification of surgical procedure determines an increased safety for the patient, this being the main reason to adopt this kind of technique for living donors. Comparing the different series of RAN, various surgical strategies exist, from the hand-assisted to the totally robotic nephrectomy, depending on the centre-by-centre experience [9–19, 21]. Robotic technology is evolving. In the next future robotic stapler will be available making the last "laparoscopic" step of this procedure safer and under robotic control. Probably a smaller robotic Ligasure will be commercialized along with a new surgical bed that could be moved without undocking the robot.

22.4 Totally Robotic Nephrectomy

22.4.1 Donor Selection

Donor selection criteria do not differ from the general accepted criteria for laparoscopic surgery. Previous multiple abdominal surgery can be considered a relative contraindication to minimally invasive donor nephrectomy (with case-by-case analysis). According to literature evidence, the left kidney has to be considered the first choice even in the presence of vascular anomalies [13].

The left kidney harvesting guarantees a longer stump of the renal vein as well as the absence of liver interposition.

The choice of harvesting the right kidney depends on the preoperative radiological detection of a clear functional dominance of the left kidney that has to be preserved in order to guarantee the donor safety. All candidates need to be informed about the risk of the conversion to the open approach.

22.4.2 Patient Positioning

After general anaesthesia, the patient is placed in completely right lateral 90° decubitus. In order to obtain an adequate exposure of the kidney region,

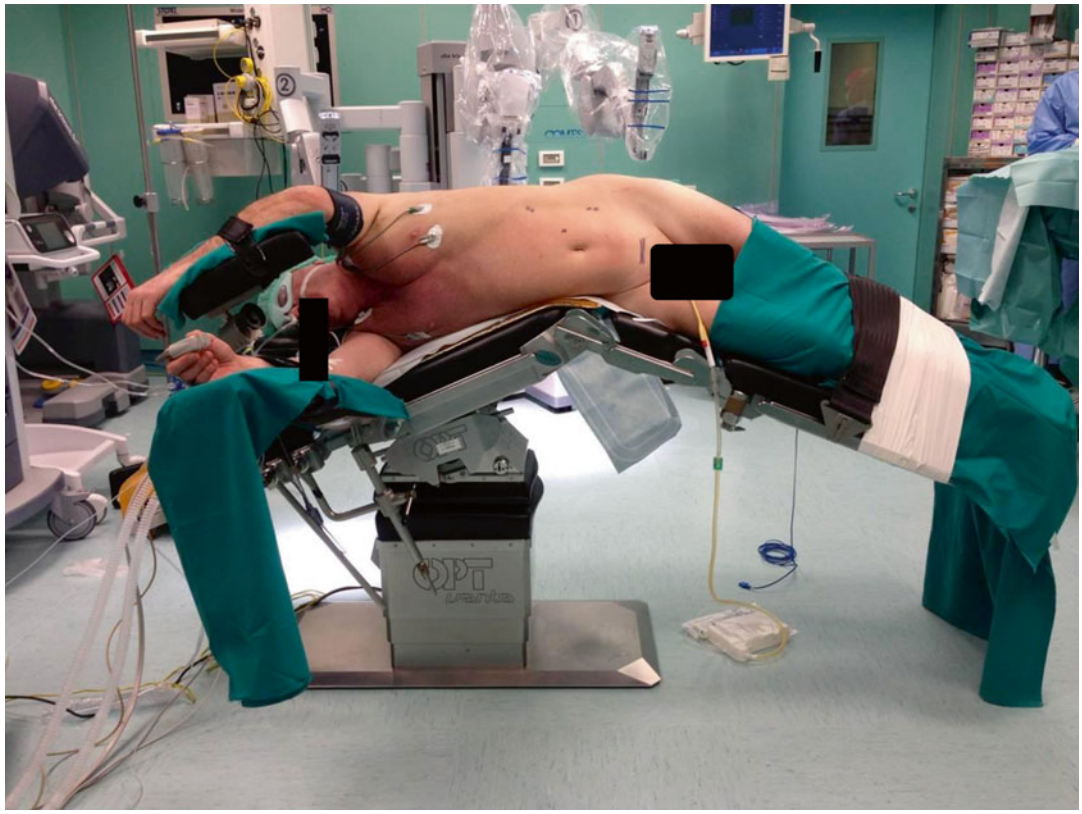

Fig. 22.8 Patient's position in totally robotic technique

the break of the surgical bed has to lay on the transtubercular plane. In order to avoid conflicts with the robotic arms, the lower leg of the patient should be bent at 90 °, while the upper leg must be completely stretched (Fig. 22.8).

22.4.3 Incision and Trocar Placement

The first surgical step is a Kustner preparatory incision of around 8–10 cm, with opening the fascia and the peritoneum.

A camera trocar (12 mm) is placed using the intra-abdominal hand control throughout the Kustner incision about 5–6 cm off the umbilical scar (on the mid-clavicular line ipsilateral to the side of the nephrectomy).

Afterwards the surgeon closes the muscle and peritoneum incision with a running suture while placing an endo-bag instrument (Endo Catch II–15 mm) throughout the fascia access and attaching it to the pelvis of the patient with adhesive strips.

It's important to leave the free margins of the running suture long enough to be easily and rapidly pulled for its cutting when extracting the kidney or in case of emergency bleeding control.

Therefore, the 12 mmHg pneumoperitoneum is induced and two 8 mm robotic trocars are placed under camera vision into the omolateral anterior axillary line, respectively, in subcostal and flank region (Fig. 22.9). Another 12 mm trocar for the assistant surgeon has to be placed in the left extreme side of the Kustner incision (Fig. 22.10).

At this time, the robotic cart is docked to the trocars from the patient's back side.

Basic access and first connected robotic instruments are a bipolar Maryland forceps controlled by the left robotic arm, a monopolar hook on the right robotic arm and a 30° videoscope. A complete summary of robotic and laparoscopic

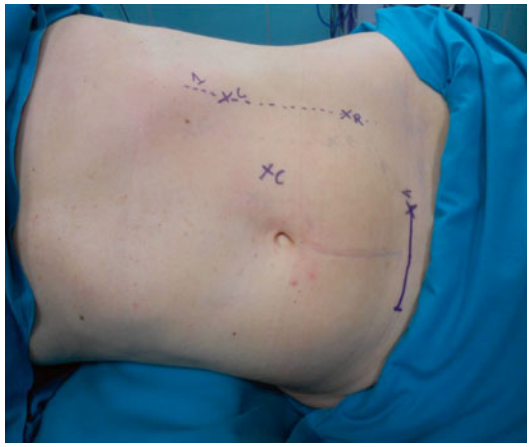

Fig. 22.9 Totally robotic technique: trocars positioning

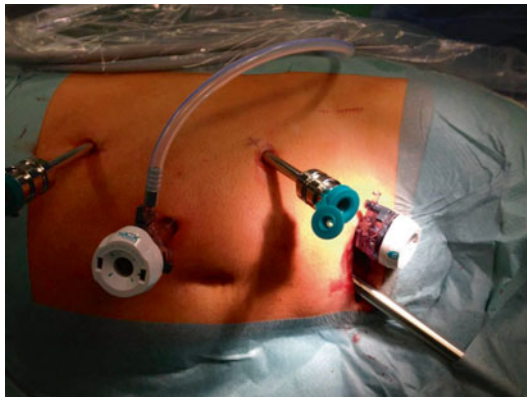

Fig. 22.10 Final trocars placement

instruments needed for the procedure is shown in Table 22.1.

Table 22.1 Laparoscopic and robotic instruments

Three robotic trocars (one 12 mm for the 30 °robotic videoscope and two 8 mm for the robotic arms)
One 12 mm trocar for the assistant surgeon at the table (plus another 5 mm trocar for right nephrectomy)
One Endo Catch II (15 mm)
Robotic instruments
Fenestrated bipolar forceps (type Maryland)
Permanent cautery hook
Precise bipolar forceps
Needle holder
Large clip applier
Round tip scissors
Laparoscopic instruments
Large grasper
Straight tip scissor
Medium metallic clip applier
Staplers
Vein : Endopath Stapler–Echelon 45
Artery : Endo-TA Stapler 30 mm

22.4.4 Left Nephrectomy

The following step is the dissection of the left colon with the exposure of the renal region followed by the dissection of the spleno-pancreatic block from the upper renal pole up to the left diaphragmatic crura.

This manoeuvre will simplify the further approach to the vessels making it also safer in case of bleeding. The ureter is detected and marked by an elastic tape. Following the gonadal vessels, the left renal vein is identified. The left renal vein has to be isolated and respectively separated from the adrenal, gonadal and lumbar veins that are cut after distal and proximal placement of metallic clips or hem-o-lock according to size. Finally, the renal vein can be encircled by an elastic tape. The upper renal pole is then dissected from the adrenal gland: the anterior and posterior kidney surface are completely dissected from the perirenal fat tissue. The dissection of the renal artery can be better obtained by approaching it from below, lifting up the inferior renal pole and can be easily completed throughout a posterior approach keeping the kidney in a medial position after its complete dissection from the posterior Gerota's tissue. Once the whole kidney is isolated from the surrounding tissues and the vessels are dissected, the ureter is cut approximately at the iliac vessels crossing side after closing its distal stump by hem-o-lock, while the proximal stump is left open. Intravenous (IV) heparin is then administered at a dose of 80 UI/kg together with a bolus of curare in order to ease the kidney extraction. At this point the left kidney is introduced into the endo-bag previously placed by the assistant surgeon who loads the kidney, leaving out only the vascular pedicles gently pulled upwards. The renal artery is stapled by

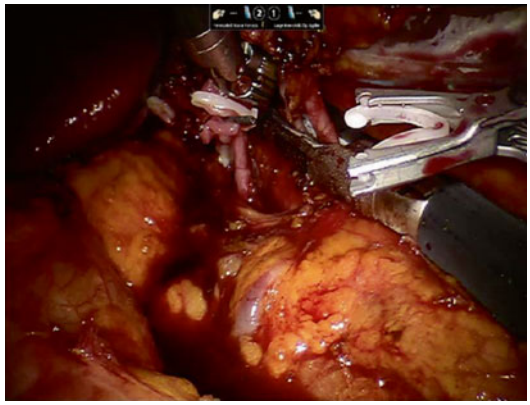

Fig. 22.11 Renal artery stapling by Endo-TA 30

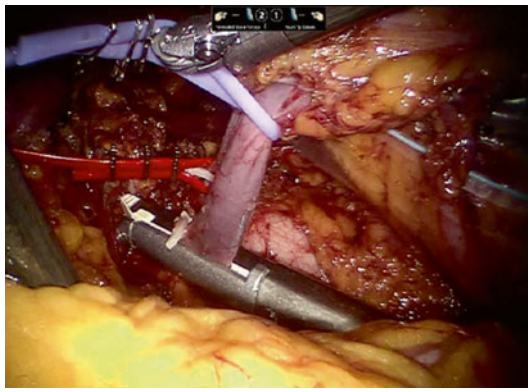

Fig. 22.12 Renal vein section by Endopath stapler (Echelon 45)

Endo-TA stapler with vascular charge at the origin from the aorta. Before cutting the renal artery with scissors, a hem-o-lock is placed on the already stapled line and the artery is finally interrupted (Fig. 22.11). Hereinafter, the renal vein is stapled and cut by a GIA Endopath stapler (Fig. 22.12).

Kidney extraction occurs by closing the endobag, undocking the robot cart, cutting the running suture of the fascia and finally pulling the kidney outside the abdomen. The last check of the left renal loggia and trocar access holes can be performed with laparoscopy after closing the minilaparotomy and after the induction of the pneumoperitoneum. At this point a bolus of protamine can be given to the patient to reverse the anticoagulant effect of heparin. The robot has to remain sterile until the end of the check, as it can be useful sometimes to stop a possible bleeding with stitches positioning. One tubular 21 French drain is finally placed on the renal bed and skin repair is usually obtained with absorbable intradermic suture (Fig. 22.13).

Fig. 22.13 Procedure completed

22.4.5 Right Nephrectomy

In right nephrectomy port placement is a mirror image of the one used for the left-sided procedure but the often needed positioning of a further 5 mm trocar in the epigastric region for hepatic lobe lifting. The right renal vessel anatomy differs from the left one. The renal vein is short and particular care has to be taken while isolating the right renal artery. It is probably safer to dissect the artery after keeping the kidney in a medial position in order to avoid damages to the vein or to its rare collateral branches.

22.5 Hand-Assisted Nephrectomy

22.5.1 Patient Positioning, Incision and Trocar Placement

After a general anaesthesia, the patient is placed in right 60° lateral decubitus position.

First surgical step is to perform a minilaparotomy by sub-umbilical midline incision of around 8 cm or a Kustner incision.

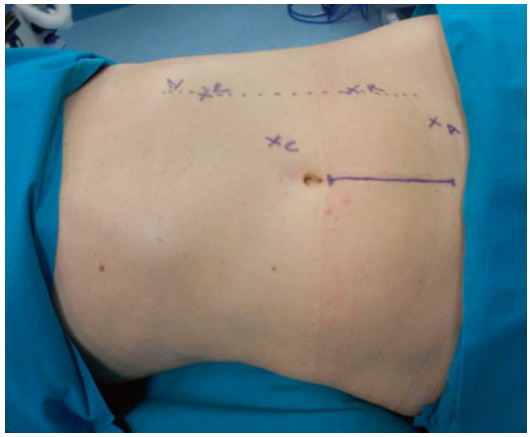

Fig. 22.14 Hand-assisted technique: trocars positioning

The 12 mm trocar for 30° videoscope is placed in the peri-umbilical region, in front of the renal hilum identified by the assistant hand, around 3 cm above the umbilicus and left lateral.

Two 8 mm robotic trocars are placed in the left lateral abdominal wall along the hemi-clavear line while another 12 mm trocar is placed in the left inguinal region for the assistant. At this time, the robotic cart is docked to the trocars from the back of the patient (Fig. 22.14). The assistant surgeon should wrap up his arm with a steri-drape in order to decrease the surgical site infection rate. The first connected robotic instruments are a bipolar Maryland forceps controlled by the left robotic arm and monopolar hook on the right robotic arm.

22.5.2 Surgical Console Time: Left or Right Nephrectomy

Kidney mobilization as well as vessels and ureter preparation and section are performed exactly in the same way, with hand-assisted or totally robotic technique. More than the expected advantage in case of a sudden need for haemostatic control, the main difference between hand-assisted and totally robotic technique lays on the extraction of the specimen that is done directly from the assistant surgeon at the surgical table. The hand can be also useful in opening the operative field by pulling away the bowel during surgery.

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