Minimally invasive donor nephrectomy for transplantation – review of surgical management

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ABSTRACT
A Kidney transplantation from a living donor is the best method of a renal replacement therapy. There are new, less invasive surgical techniques, which include videoscopic methods such as laparoscopy, retroperitoneoscopy with their modifications i.e. hand-assisted videoscopy, SILS, NOTES and robotic surgery. Videoscopy and robotic surgery are classified as minimally invasive techniques and are the future of kidney transplant surgery. In comparison to the open nephrectomy they are connected with less number of complications and very low risk of death, so this methods are in a group of surgeries safe for the donor. Besides, every donor is covered for a lifetime of medical control system. Videoscopy is commonly used and the robotic surgery is fast developing and becomes popular, because of many advantages, which does not have any other available method. The key objective is safety of the donor and that is very important thing to choice the most optimal surgical technique in a case of living donor nephrectomy. The aim of this publication is to sum up surgical management and techniques used in living organ donations to transplantation.
INTRODUCTION

Kidney transplantation from a living donor is the best method of renal replacement therapy. It is associated with longer graft and recipient survival, better quality of life, lower costs of treatment in comparison to dialyses, and preemptive transplantation feasibility, so that the patient has an opportunity to avoid dialyses and related complications [1, 2]. The first transplantation from a living donor took place in 1954 in Boston. It was performed by J. E. Murray and J. H. Harrison, between identical twins using the classical open method. The constant development of technology and medicine, has enabled the introduction of new, less invasive surgical techniques, which include videoscopic techniques: laparoscopy and retroperitoneoscopy, with their modifications, i.e. hand assisted videoscopic methods. The most advanced and the most promising techniques include robotic surgery. The world’s first kidney transplantation from a living donor, using da Vinci robot, was carried out in Illinois, in 2000. The usage of minimally invasive procedures improves the results of renal transplantation and minimizes the number of complications, resulting in a positive effect on increasing the number of transplantations[3].

The aim of this publication is to sum up surgical management and techniques used in living organ donations to transplantation.

VIDEOSCOPY

Videoscopic methods include laparoscopy and retroperitoneoscopy with modifications, i.e. hand assisted videoscopy. The advantages of minimally invasive techniques include less postoperative pain, smaller scar, shorter hospital stay and faster return to normal activities after the procedure in comparison to classical techniques. At the same time, the results of transplantation are comparable with classical techniques. Laparoscopy is currently the technique of choice in in living donors. Fewer complications and better cosmetic effects associated with using minimally invasive techniques resulted in a significant growth in the number of donors [4, 5, 6, 7].

LAPAROSCOPY

The first laparoscopic living donor nephrectomy was carried out by Ratner and colleagues in 1995[8]. Since then the technique has been developed and now it is the method of choice in kidney transplantation from living donors. The surgical technique is as follows: the patient is laid on his/her side opposite to the donated kidney. In the peritoneal cavity pneumoperitoneum is achieved by insufflation of CO₂ to 12 mmHg. The number of trocars depends on, which kidney is collected. In case of left-sided nephrectomy, three trocars are used, placed in sequence: the first- in the middle of the line connecting the umbilicus and the costal margin in the midclavicular line; the second- below the costal margin in the midclavicular line; the third- the middle of the line connecting the umbilicus and the anterior superior iliac spine.

Successive operating steps are:
- colon and spleen mobilization
- identification of the ureter and division at the level of the iliac vessels
- dissection of the kidney and the renal vessels
- closure using stapler and division of the renal vessels
- additional incision in the abdomen (Pfannenstiel incision), to enable removal of the kidney.

In case of the right-sided nephrectomy, additionally a fourth trocar located in the median line is used, placed 1 cm below distal end of xiphoid process of sternum, through which a retractor is placed to hold the liver, in order to expose the front surface of the kidney.

Successive operating steps are:
- mobilization of the duodenum
- identification of the ureter and its division at the level of the iliac vessels
- dissection of the kidney and the renal vessels
- closure using stapler and division of the renal vessels
- additional incision in the abdomen (Pfannenstiel incision), to enable removal of the kidney.

In both right and left-sided nephrectomy, the kidney is placed in an endobag and removed from the abdominal cavity. Then the organ is flushed at 4°C temperature [9, 10, 11].

At the beginning of the era of laparoscopic techniques, left-sided nephrectomy was preferred. Right-sided nephrectomy was associated with a higher number of complications and was technically difficult due to anatomical reasons (right renal vein is shorter). Multiple renal arteries were also a problem, which significantly increased the number of technical difficulties during surgery. In the light of current research, the results of right and left-sided nephrectomy are comparable. Also, using organs with multiple arteries is no longer a problem and it is not associated with longer operating time, longer WIT or higher risk of complications [8, 12, 13].

Using modified Endo GIA Stapler, it is possible to obtain a suitable length of the renal vein during laparoscopic kidney nephrectomy and to make anastomoses without prior venous reconstruction which shortens cold ischaemia time. It also allows for full control of hemostasis after division of the vessel [13]. In comparison to the open technique, the advantages of laparoscopic kidney living donor nephrectomy are: lower postoperative pain, shorter hospitalization time (about 5 days) and faster recovery time, better cosmetic result and better graft function [14, 15]. Disadvantages are seen in: longer operating time
In case of laparoscopic living donor nephrectomy, the risk of death of the donor is very low and ranges from 0.02 to 0.03%; among the most common causes of death are massive bleeding from the stump of the renal artery and pulmonary embolism are mentioned. The risk of massive intraoperative bleeding is in the range: 0.6-1.6%, and conversion to the open operation is performed in 0% -13% of the cases. The incidence of complications after this type of surgery is approximately 10% [4].

In addition to traditional laparoscopy, laparoendoscopic single-site live-donor nephrectomy (LESS-DN) is described. In this method a single access port is used. This is a more difficult technique because the maneuvering tools are inserted only through one port, which is associated with a limited range of movements. The procedure lasts longer and requires a great deal of skills from the operator, however, it is associated with shorter recovery time and less postoperative pain and there is no negative impact on the results of transplantation. This technique can be successfully used also in case of obese donors. Due to the high technical difficulty, this method should be used in centers specializing in SILS [2, 17].

Living donor nephrectomy is also possible using the technique which is called E-NOTES (embryonic natural orifice transluminal endoscopic surgery) and NOTES (existing natural orifice transluminal endoscopic surgery). The first living donor nephrectomy using this technique was performed by Inderbir S. Gill in 2007 [18]. The surgical access is prepared using natural body orifices. It can be achieved through the wall of the stomach and the rectum, the vault of the vagina, gallbladder and it is also possible through the umbilicus (E-NOTES). This technique offers a very satisfactory cosmetic result. Using natural body orifices, which have their own rich bacterial flora is associated with a high difficulty in maintaining the sterility of the operating field and therefore, higher risk of surgical site infection. The disadvantage of this technique is also the associated great technical difficulty [13, 19].

The surgical technique using access through the vagina:

Donor is under general anesthesia, and placed in the lateral decubitus position. Then the 10-mm trocar is placed in the umbilicus, and pneumoperitoneum is achieved. Next, a 10-mm trocar is placed in the left iliac fossa, then a 5-mm grasper is placed next to the ribs. The last, 12-mm, trocar is placed through the vagina, under direct vision to avoid intestinal rupture. Dissection is performed in the same steps as in a standard laparoscopy. The kidney is placed in the bag and then removed through the incision in vagina. Then it is important to remove the kidney from this bag, avoid contact with external side of bag, because of the risk of contamination. The last steps consist of vaginal incision closure, checking hemostasis and wound closure after removal of trocars [20, 21].

**RETOOPERITONEOSCOPY**

Retroperitoneal space is a potential space. Obtaining workspace is possible using rubber glove and making a “balloon” with it. After placing it in the retroperitoneal space it is filled with air or physiological saline. The first trocar is placed at the site of the previous incision, through which the workspace was achieved. This incision is wider than trocar, thus fixing of the device is necessary, which prevents the escape of gas after the formation of workspace and stabilizes the trocar. The incision is located below the tip of the 12th rib or in the inferior lumbar (Petit’s) triangle. Next, two further trocars are placed under direct vision, one at the renal angle and another one in the anterior axillary line. First the kidney is mobilized, then the renal vessels [9, 22].

In case of retroperitoneoscopy, retroperitoneal access minimizes the risk of intraperitoneal organ rupture, which is why it is an alternative to standard laparoscopy, especially because of lower risk of bowel and spleen damage. The next advantage is direct access to the renal vessels. Creating the workspace is a safe maneuver because of a very low risk of vessel injury during this activity. A disadvantage of this method is its higher technical difficulty in comparison to laparoscopy, which is caused by the smaller workspace [11, 22, 23, 24, 25].

Intraoperative complications include the risk of the rupture of the glove “balloon”(which can be simply reduced by using two fingers of rubber gloves) and subcutaneous emphysema [22].

This technique is particularly beneficial in case of obese donors and donors with history of abdominal surgery [26].

High donor safety and good graft function show that retroperitoneoscopy is a great alternative for laparoscopy [27], especially when the hand assisted technique is used [26, 28, 29, 30]. In Department of General and Transplantation Surgery retroperitoneoscopy is preferred in case of living donor. Retroperitoneal donor nephrectomy is used by authors and steps for that observation can be seen on film 1.

The mentioned modification of these techniques by using hand assisted technique reduces intraoperative complications, mainly by better control of bleeding. This method allows for better identification of struct-
tures and reduces the risk of kidney damage during surgery, faster organ removal and also shortens the warm ischemia time and operating time (in case of HARP– surgical time is about 159 min, in case of HALDN– about 190 min). The risk of damage to the abdominal organs is lower. Because the method is technically easier, learning curve is shorter. The disadvantage of hand assisted methods lies in making an additional incision, through which the hand of the surgeon is inserted (which is associated with higher risk of emphysema, poorer wound healing, larger scar, possible hernia and pseudohermia) [1, 3, 15, 26]. Hand assisted laparoscopic donor nephrectomy (HALDN) is similar to the standard laparoscopy with the difference that the hand of the operating surgeon can be placed through an air-tight port which is called a gelport, through which the surgeon dissects the tissue and mobilizes the kidney. Retroperitoneoscopy could also be performed with hand assistance (HARP), and such a procedure was described for the first time in 2000 [11, 31].

Costs of retroperitoneoscopy and laparoscopy are similar, which means that the choice of method should be based on which technique is the most optimal for the donor [32].

ROBOTIC SURGERY

As mentioned, laparoscopy is the method of choice in case of living donor nephrectomy. Despite very good results, video-scopy techniques have some limitations such as an incomplete range of maneuvers and imaging in two dimensions. These problems were solved using robotic surgery. This method includes the da Vinci system. There are other robotic systems as AESOP, or ZEUS, but in comparison to da Vinci, they produce inferior results and they are not available currently [33]. In case of robotic surgery, there is a three-dimensional imaging and there are „endowrist instruments”, that provide a full range and accuracy of movements identical to the human wrist. In addition, the surgeon position during the operation is highly ergonomic, which provides better reproducibility of results and is more comfortable for the doctor. These are important factors in case of long-lasting procedures, because it can affect the result of surgery and patient’s safety [34, 35, 36].

The robotic technique is very precise and minimally invasive, and the time of operation (about 166 min) and the risk of complications are comparable to videoscopy. The benefits of robotic surgery also are the possibility of obtaining longer renal vessels, less blood loss and less postoperative pain. The advantage is also a better cosmetic result and lower risk of injury to surrounding tissues by making access through the orifices up to 2 cm in diameter and quicker return to full activity after surgery [15, 16, 37]. Despite many advantages, this is a more expensive technique than videoscopy. The cost of performing such a procedure is comparable to videoscopy, while the difference is caused by the price of robotic system and its maintenance.

Surgical technique:

Patient in general anesthesia is placed in a lateral position, at an angle of 60° in order to increase the distance between costal arch and iliac fossa, on side opposite to the chosen kidney. The platform tool is placed behind the donor. The surgeon is next to the control panel and operates two pedals and two manual transmissions, the image on the monitor is zoomed 10-fold in, where the image is presented in 3D and comes out of the camera mounted on a robot arm. The surgeon has control tools, and the movements are converted in real-time to movements of surgical instruments located on the 4 arms of the robot (there are also robots with 3 arms, where two have surgical tools and the third contains an endoscopic camera). Robotic arms have 7 degrees of freedom. Tools copy the movements of the hand, wrist and thumb precisely (endowrist technology), eliminating tremor and compensating for too rapid movements of the surgeon’s hand. Laparoscopic tools (to cut, dissect or to suture) and the endoscope are placed in the arms of the tool. The first trocar, 12 mm, in diameter, is placed in the periumbilical region (above the umbilicus, close to the midline, at the level of the renal hilum) the camera is inserted through. Next, 2 or 3 trocars, 8 mm in diameter, are for robotic tools and are located in the lateral abdominal wall along the midclavicular line. Two 10+ mm trocars are for the surgical assistant and they are placed in the left inguinal region. Pneumoperitoneum is achieved. After kidney dissection, identification of the ureter and renal vessels and their division, the organ is removed through a small, 7 cm incision (Pfannenstiel incision). Next there is the control of hemostasis, disconnection of the robotic system, removal of ports and closure of wounds [16, 37].

Just as in case of standard laparoscopy, right kidney is less preferred due to the shorter length of renal vein. Ports are placed in the same configuration mirroring left side nephrectomy access. Occasionally, one additional port is placed in the left upper quadrant for liver retraction. After medial mobilization of the right colon, the ureter is identified and the IVC is exposed. Occasionally, the Kocher maneuver may be necessary. Pneumoperitoneum is obtained and after kidney dissection, identification of the ureter and renal vessels, and dividing them, the organ is removed through a small, 7 cm incision (Pfannenstiel incision). Next steps are the control of hemostasis, disconnection of the robotic system, removal of ports and closure of wounds [9, 37].

Robotic surgery can also use hand assistance (third surgeon). The risk of intraoperative bleeding in case
of this method is very low, and hand assistance further decreases the risk of blood loss. Despite the infrequency of intraoperative bleeding we cannot forget about it, because it is a very dangerous, life-threatening complication [38]. Generally in case of robotic surgery, the number of complication is low and the majority of them occur in the initial period of application of this method by the center [37].

SUMMARY

Kidney transplantation from living donors is the best treatment for patients with end-stage renal disease. The patient has the opportunity to receive an organ preemptively, period, at the most optimal time. A living donor nephrectomy is particular in that a kidney is removed from a healthy person. The key objective is the safety of the donor and that is why we comprehensively and thoroughly check the condition of the donor’s health and always take the kidney with poorer function. The choice of surgical technique is crucial. Videoscopy and robotic surgery are classified as minimally invasive techniques and are the future of kidney transplant surgery. In comparison to the open nephrectomy they are associated with less complications. The most common complication is pain in the operative field, sustained for several days. Less frequent complications include urinary tract infections, wound infection, hernia and pseudohermia. In extremely rare cases the donor could die during the surgery. Despite the risk of complications, their number is very low, and it is comparable to the risk of death in case of appendectomy, which includes this procedure in a group of surgeries safe for the donor. Videoscopy and robotic methods, which are less invasive and safer, increase the number of living donor nephrectomies. Videoscopy is commonly used and robotic surgery is developing rapidly, becoming increasingly popular, due to many advantages not available in other methods. In 2012 20 000 procedures were performed using this method. Despite the fact that there are many arguments for videoscopy and robotic surgery, we have to remember also about the existence of the open technique, which is still the best alternative for many donors.

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34. http://medtube.net/tribune/da-vinci-robot/


