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Robot-Assisted Nephrectomy in a Living Kidney Donor – a Case Report

Robotski asistirana nefrektomija u živog darivatelja – prikaz slučaja

Dean Markić[1, 2*], Gabriela Berlakovich[3]

[1] Clinical Hospital Centre Rijeka, Department of Urology, Rijeka, Croatia

[2] University of Rijeka, Faculty of Medicine, Rijeka, Croatia

[3] University Hospital Vienna, Division of Transplantation, Department of General Surgery, Vienna, Austria

Abstract. ***Aim:*** The use of minimal-invasive surgical methods in kidney donation surgery led to an increased number of living kidney donors. The laparoscopic donor nephrectomy has become the gold standard for living kidney donation but nowadays the robot-assisted nephrectomy for living kidney donation (RADN) has been performed in expert centres. We present a case of RADN followed by a successful kidney transplantation. ***Case report:*** The 77-year-old man with adult polycystic kidney disease gradually progressed to end-stage renal disease and started with dialysis in December 2022. After extensive assessment, his 61-year-old sister was prepared to be a donor. In September 2023, a successful RADN was performed. The left kidney was procured. The kidney was successfully transplanted to the recipient with a cold ischemia time of 4 hours and 30 minutes. The postoperative course was uneventful for both donor and recipient. Three months after surgery the renal function is stable in both patients. ***Conclusion:*** The RADN is a safe and effective method with comparable results to laparoscopic donor nephrectomy used in centres with robotic surgery.

Keywords: kidney transplantation; living donors; nephrectomy; renal insufficiency; robotic surgical procedures

Sažetak. ***Cilj:*** Uvođenje minimalno invazivnih metoda u donorsku kirurgiju dovelo je do povećanja broja živih darivatelja bubrega. U današnje se vrijeme laparoskopska donorska nefrektomija smatra zlatnim standardom, no broj se robotski asistiranih donorskih nefrektomija (RADN) povećava. Prikazat ćemo bolesnika u kojega je učinjen RADN i posljedična uspješna transplantacija bubrega. ***Prikaz slučaja:*** U 77-godišnjeg bolesnika s adultnom policističnom bolešću bubrega došlo je do progresije u terminalni stadij bubrežnog zatajenja te je u prosincu 2022. započeo s dijalitičkim liječenjem. Nakon opsežne obrade njegova 61-godišnja sestra prihvaćena je kao donor. U rujnu 2023. učinjen je RADN, a odstranjen joj je lijevi bubreg. Slijedila je uspješna transplantacija bubrega, a hladna ishemija trajala je četiri sata i 30 minuta. Poslijeoperacijski tijek bio je uredan u darivatelja i primatelja. Tri mjeseca nakon operacije bubrežna funkcija bila je stabilna u oboje bolesnika. ***Zaključak:*** RADN je sigurna i efikasna metoda s podjednakim rezultatima kao i kod laparoskopske donorske nefrektomije, a provodi se u centrima gdje se radi robotska kirurgija.

Ključne riječi: bubrežna insuficijencija; nefrektomija; robotski asistirana kirurgija; transplantacija bubrega; živi darivatelji

[*]**Corresponding author:**
Assoc. prof. Dean Markić, MD
Clinical Hospital Center Rijeka,
Department of Urology
Tome Strižića 3, 51000 Rijeka, Croatia
E-mail: dean.markic@medri.uniri.hr

http://hrcak.srce.hr/medicina

INTRODUCTION

Kidney transplantation (KT) is the best treatment modality for the treatment of end-stage renal disease (ESRD). The overall number of KTs (kidney only) in Eurotransplant from deceased donors in 2023 was 2983. Out of that number, there were 239 KTs in Austria, 123 in Croatia and 50 in Slovenia[1]. The absolute number of donors in Croatia (2023) was 116, e.g. 30 donors per million population which is one of the highest in the Eurotransplant and the world. Still, 242 Croatian patients were on the KT waiting list at the end of 2023[2].

Minimally invasive surgical techniques significantly increase the number of living donors. This improvement is generated by a reduction in postoperative pain, decreased hospitalisation time, better cosmetic results, and equal outcomes compared to open surgery.

Increasing of living kidney donors is one of the ways to increase the number of KT, especially in countries such as Croatia where the rate of KT using living donors is very low. Also, KT using living donation is connected with better graft and patient survival, lower rejection rate, shorter cold and warm ischemia time compared to KT using deceased donors[3]. The open surgery was for decades the main approach for living kidney donation but is associated with increased postoperative pain and more significant scarring[4]. Minimal-invasive techniques (laparoscopic and robotic-assisted approach) which provide less pain, faster recovery and return to normal activities with better cosmetic results and equal outcomes become more popular for a living donor nephrectomy[5]. We will present the KT in which the robotic-assisted nephrectomy was performed in a living kidney donor (RADN).

A CASE REPORT

A 77-year-old Caucasian male patient and his 61-year-old sister were admitted to the Division of Transplantation, Department of General Surgery, University Hospital Vienna for a planned living kidney donation. The recipient (male patient) had an adult polycystic kidney disease (APKD) as a cause of ESRD. He started with haemodialysis in December 2022 and he had concomitant anaemia and hyperparathyreoidismus, diabetes mellitus type II with polyneuropathy and used a substantial number of medications. Previously he had performed transurethral resection of the prostate, hip replacement, and thyroidectomy. His physical examination revealed that we had an adipose patient (BMI=33.2 kg/m^2). Preoperative haemoglobin level was 10.8 g/dL, haematocrit 32.5%, creatinine value 3.87 mg/dL (after dialysis), urea 23.0 mg/dL (after dialysis) and eGFR 15,2 ml/min. The anaesthesiologist assessed him as ASA 3 and MET 4-5.

His sister, the donor, was a retired woman. She had hyperlipidaemia and was taking atorvastatin. Previously she had a caesarean section and appendectomy. She had a nicotine dependence. Her physical examination was completely normal with a BMI of 25.2 kg/m^2. Laboratory data were normal. Preoperative haemoglobin level was 13.0 g/dL, haematocrit 40.8%, creatinine value 0.74 mg/dL and eGFR 111 ml/min. There were no erythrocytes in the urine. The anaesthesiologist assessed her as ASA 1 and MET 5-10.

For both donor and recipient, an extensive assessment was performed. This assessment included laboratory testing (blood chemistries, liver function tests, complete blood count, coagulation profile), infectious profile (Hepatitis A, B, and C serologies, Epstein-Barr virus serologies, Cytomegalovirus serologies, Varicella-zoster virus serologies, Rapid plasma reagin [RPR] test for syphilis, HIV, Interferon-gamma release assay for tuberculosis (QuantiFERON Gold In-Tube]), urinalysis and urine culture, cardiac evaluation, imaging methods (ultrasonography, CT, renal scintigraphy), immunologic evaluation (ABO blood group determination, human leukocyte antigen [HLA] typing, serum screening for antibody to HLA phenotypes and crossmatching) and psychological evaluation. The crossmatch was negative, and HLA testing showed good histocompatibility.

The donor abdominal CT scan with contrast revealed normal kidneys, both with one main renal artery and one smaller polar artery directing from the aorta. Bilaterally one renal vein was no-

ticed with a normal ureter and a pyelocaliceal system. Renal scintigraphy showed that function of the right kidney was 46% and the left kidney 54%.

The recipient also performed an abdominal CT scan in which enlarged, bilateral, polycystic kidneys were observed (right kidney diameter of 24 cm versus 19 cm on the left side) and the external iliac arteries were without significant atherosclerosis.

Preoperatively both patients were assessed by a transplant surgeon. The left donor kidney was chosen for nephrectomy (longer renal vein) with planned kidney transplantation in left iliac fossa (more space for implantation because of the smaller native polycystic kidney).

Both patients had an adequate psychological evaluation which revealed their will to donate and receive organ.

Before the operation the donor received, as a standard procedure, prophylactic antibiotic and low-molecular weight heparine. For donor nephrectomy the robotic system da Vinci Si® Surgical System was used (Intuitive Surgical, USA) (Figure 1). The patient was placed in a right 45° lateral decubitus position. Under general anaesthesia and sterile conditions, the 12 mm camera trocar was placed next to the umbilicus. Pneumoperitoneum was maintained at 12 mmHg using AirSeal®, Conmed, USA. The 3 trocars (8 and 12 mm) for the robotic arms were subsequently placed in an imaginary semi-circular line equidistant to the camera. In the lower abdomen, using a previously performed Pfannensteil incision, the Alexis® laparoscopic system (Applied Medical, USA) was inserted and through it another 10 mm trocar used by the assistant for suction-irrigation, introduction, and removal of suture materials and clip application was placed. The "docking manoeuvre", which virtually means connecting the robotic arms with all trocars, was performed after the robot was properly positioned. Standard instruments used for operation include comprised hot shears (MSC), fenestrated bipolar forceps, Cadiere forceps, and a large SutureCut needle driver. The descending colon was mobilised and displaced medially to allow the opening of the Gerota's fascia. In the first step the ureter was identified at the level of the iliac axis and dissected free up to the lower pole of the kidney preserving the periureteral tissue commonly known as "golden triangle". After dissection of the lateral and posterior region of the kidney the renal vein was dissected free as possible to their outlet into the inferior vena cava, and its branches (lumbar, gonadal, and adrenal) were clipped and transected. In a subsequent step, the two renal arteries were identified and dissected free up

Figure 1. Robotic system da Vinci Si® Surgical System (Intuitive Surgical, USA) during surgery (with permission from the personal archive of Prof. Berlakovich).

almost to the level of their aortic origin. When the kidney was completely mobilized, the ureter got transected with EndoGIA® stapler (Medtronic, USA) and divided. Subsequently, the kidney was placed into an endobag for extraction. Before removal of the wrapped kidney through a Pfannenstiel incision, the renal arteries and renal vein were transected using EndoGIA® vascular staplers (30 mm for arteries, 45 mm for vein). The kidney was extracted manually in an endobag through Alexis® laparoscopic system and put in a sterile surgical bowl which was lying in the ice. The kidney was perfused with ice-cold perfusion solution (Custodiol®, Dr Franz Kohler Chemie, Germany) until the clean perfusion solution exited from the renal vein. Before wound closure the renal bed and vascular stumps were inspected for bleeding. All trocars were removed under direct vision during evacuation of the pneumoperitoneum. The duration of the operation was 226 minutes.

Back-table surgery includes defatting the kidney and preparing the renal vessels and ureter for implantation. The kidney had one large renal vein. Since there were metal clips in close proximity with the renal vein ostium (ligating adrenal, lumbar, and gonadal branches) the clips were eliminated, and these vessels secured with Prolene 6-0. The two renal arteries were conjoined using Prolene 7-0. The kidney biopsy was performed using a special instrument. The kidney was put in three sterile bags (containing cold perfusion solution) and in the container with ice.

Kidney transplantation was performed in the left iliac fossa using hockey stick incision. Adequate space for the kidney was created and iliac vessels were prepared. Renal vein was terminolaterally anastomosed to the external iliac vein using Prolene 5-0 and renal artery was terminolaterally anastomosed to the external iliac artery using Prolene 6-0. For both anastomoses one-suture technique was used. After declamping the vessels, homogeneous reperfusion of the kidney was noticed without any significant bleeding from the kidney and the ureter was implanted in the urinary bladder using the extravesical Lich-Gregoir technique. JJ endoprosthesis was intraoperatively inserted. A redon drain was placed in the extraperitoneal space and the abdominal wall was subsequently closed. The duration of the kidney transplantation was 147 minutes. The duration of cold ischemia time was 4 hours and 30 minutes.

Postoperative course of the donor was uneventful. The postoperative haemoglobin in the donor was 11.4 g/dL, haematocrit 34.5%, creatinine 1.23 mg/dL and eGFR >70 ml/min. It is obvious that the blood loss during the operation was minimal. The urinary catheter was removed on postoperative day 2. During the stay in the hospital, she received low-molecular weight heparin. The donor was discharged five days after the operation. She would visit her family doctor ten days after the operation to remove the skin sutures and would be periodically followed by a nephrologist (monitoring kidney function, glucose, and blood pressure).

Recipient postoperative course was also uneventful. The kidney function was gradually established after transplantation. Ultrasonography of the kidney showed good perfusion of the kidney with resistance index between 0.70-0.88. The drain was removed on the third day after operation and urinary catheter was removed on the fifth day after operation. During the stay in the hospital, he received low-molecular weight heparin and prophylactic antibiotics. He also received immunosuppressive medication including antirejection induction agent (humanized monoclonal antibodies-basiliximab) and maintenance immunotherapy agents (prednisone, mycophenolate mofetil, and tacrolimus). The recipient was discharged from the hospital on the fifteenth day after the operation. Extraction of the JJ stent was performed 8 weeks after the transplantation. The recipient was closely followed by a transplant surgeon and nephrologist.

DISCUSSION

Traditionally, kidney donor surgery was performed as an open surgery using a flank incision. Recently, the minimally invasive techniques were used because of decreased postoperative pain, faster recovery, and better cosmetic results. Laparoscopic nephrectomy was first introduced, and nowadays robotic-assisted nephrectomy has become more popular.

The first laparoscopic donor nephrectomy (LDN) was performed in 1995[6]. Good functional outcomes with less postoperative pain, shorter hospitalisation, faster return to normal activity, and improved cosmetics have resulted in increasing numbers of living donors since the adoption of the laparoscopic technique[7,8]. LDN has been performed in increasing number of cases, both for hand-assisted and for completely laparoscopic procedure. Multiple studies demonstrated that their results are comparable with open surgery and today LND became the gold standard for donor surgery[9]. Still, the disadvantage of LDNs is a longer warm ischemia time and the operation time compared to open surgery[10].

Robotic-assisted surgery recently has become more popular because of the clear advantages of using wristed and tremor-free instruments, three-dimensional vision with magnification which are better than those offered by laparoscopy. Last but not least, the sitting position of the surgeon is more comfortable. These led to the implementation of robotic-assisted surgery in different fields of medicine including kidney donation surgery. Notable, this procedure has high logistical administration and high costs. However, especially in obese patients or in case of complex anatomy there is an advantage of robotic-assisted operation compared to the laparoscopic.

The first series of RADN was published by Horgan et al. in 2002. including 12 patients[11]. Nowadays, RADN accounts for about 4% of all minimally invasive donor nephrectomies[12]. In 292 patients with RADN performed in the six centres the average donor age was 40.2 years with female predominance[13]. Left nephrectomy was performed in 282/292 (96.6%) patients. 28% of patients have >1 renal artery and 1,7% patients have >1 renal vein. The technique of vessel stapling included an endo-stapler and/or Hem-o-lock clips but with endo-stapling predominance (specially for the vein). Incision for the graft extraction was infraumbilical, Pfannenstiel, transvaginal, transumbilical and Kustner. The average warm ischemia time was 3.5 minutes (range 0.58 to 7.6). Most frequent intraoperative complication was acute hemorrhage in 5/292 (1.7%) patients. The average overall intraoperative blood loss was 67.8 ml (ranged 10 to 1500). In 4/292 (1.4%) patients' operation was converted to open surgery due to intraoperative haemorrhage. Perioperative complications occurred in 37/292 (12.6%) patients. The average overall operative time was 192 minutes (range 60-400). Length of hospital stay was an average of 2.7 days (range 1 to 10). All donors had complete normalisation of renal test before discharge. No case of donor death occurred. The five points that are emphasized as advantages of this method are: higher dissection facility, easier suturing and knotting, more accurate graft preservation, a faster learning curve for the surgeons and extremely higher surgeon's comfort. The main disadvantage is the cost of the robotic system[13].

Robotic-assisted nephrectomy for living kidney donation has become a well-established procedure in expert centres. Their results are comparable with laparoscopic donor nephrectomy which is today the gold standard for living kidney donation surgery.

Khajeh and colleagues analysed outcomes between LDN and RADN[14]. In this meta-analysis 6970 donors (6143 as laparoscopic group and 827 as robotic group) were included. Blood loss and warm ischemia time were shorter in the LDN group. Conversion to open surgery, operation time, surgical complications, hospital stay, costs, and delayed graft function were similar in both groups. They also noticed that operation time and length of hospital stay were shorter and the rate of conversion to open surgery and overall surgical complications were lower in experienced RADN surgeons compared to experienced LDN surgeons. These facts support the opinion that RADN could become the method of choice for living kidney donation since surgeons have adequate experience in robotic surgery[14]. However, prospective controlled trials are needed for comparison between RAND and LDN to show which method should be preferred.

The recent French study included 118 patients with RADN and subsequent KT followed up to 48 months[15]. The RADN median operative time was 120 min, median warm ischemia time was 4 min-

utes with an average of 50 ml of blood loss. Three patients (2.6%) had intraoperative complications including 2 venous injuries treated with prompt control of haemostasis (no need for blood transfusion) and one cardiorespiratory arrest lasting 3 seconds with spontaneous resolution (unknown cause of arrest). Nine (7.6%) donors had postoperative complications including seven grade I, one grade II (blood transfusion) and one grade IIIb (vaginal bleeding after VE) complication. Conversion to open surgery was not needed in any patient. The recipients' median operative time was 120 minutes. Two patients had kidney transplant failure caused by arterial thrombosis (during KT) and arterial dissection (on 4th day) and transplantectomy was performed. In another patient, transplantectomy was performed 5 months after KD because of resistant acute immune rejection. Donor kidney function decreased from 92.0 mL/min/1,73 m^2 preoperatively to 60 mL/min/1,73 m^2 postoperatively and remained stable for 24 months. No death occurred in the donor population. The recipient kidney function recovered after KT and median postoperative renal function was 60 mL/min/1,73 m^2 at 6 months and 57.5 mL/min/1,73 m^2 up to 48 months after operation. Five patients were required to return to dialysis within 48 months from KT because of rejection. Three recipients died during follow-up (one suicide, one myocardial infarction, one septic shock)[15].

From our patient we can obviously see all the benefits of robotic-assisted operation: minimal-invasive procedure with good final cosmetic result, excellent exposure of targeted organs (kidney) during operation despite the anatomical variation, minimal blood loss, reduced stay in the hospital, and fast return to normal activity. Last but not least, all principles of donor surgery (adequate renal vessels and ureter) are achieved as in the open surgery.

One of the major issues in the field of minimally invasive living kidney donation surgery is the control of the main renal vessels. In most of the laparoscopic nephrectomies for kidney tumours vascular locking clips and stapler devices are used. These techniques were transferred to living kidney donation surgery. Due to a few fatal haemorrhagic events the US Food and Drug Administration (FDA) and the manufacturer stated that the use of locking clips for renal artery in kidney donation surgery is contraindicated. Other possible techniques included intracorporal knot tying, bipolar vascular sealing devices, ultrasonic shears, and their combination with clips, but still the vascular staplers and clips remain the prevalent techniques for renal vessel control[16]. The possible reason why vascular clips are not completely replaced with staplers is that stapler use is connected (rarely) with their malfunction, renal vessel shortening and increased operative costs. That is the reason why all the above-mentioned modalities for renal vessel control are used during RADN. In future, special robotic instruments will probably be developed for secure vessel control.

CONCLUSION

Minimal-invasive techniques are the most utilized methods for kidney donation surgery, especially in developed countries. The RADN, used in expert centres, is a promising new technique with comparable outcomes to LDN.

Annotation

The written and signed informed consent was obtained from the donor and recipient for this article.

Conflicts of Interest: Authors declare no conflicts of interest.

REFERENCES

1. Eurotransplant [Internet]. Eurotransplant statistics [cited 2024 May 18]. Available from: https://www.eurotransplant.org/statistics/.
2. Ministarstvo zdravstva Republike Hrvatske [Internet]. Zagreb: Nacionalni transplantacijski program, c2024 [cited 2024 May 18]. Available from: https://zdravlje.gov.hr/UserDocsImages/dokumenti/Tekstovi%20razni/NACIONALNI%20TRANSPLANTACIJSKI%20PROGRAM%202021%20-sa%C5%BEetak.pdf.
3. Ibrahim HN, Foley R, Tan L, Rogers T, Bailey RF, Guo H et al. Long-term consequences of kidney donation. N Engl J Med 2009;360:459-69.
4. Xiao Q, Fu B, Song K, Chen S, Li J, Hiao J. Comparison of surgical techniques in living donor nephrectomy: a systematic review and Bayesian network meta-analysis. Ann Transplant 2020;25:926677.
5. Rudow DL, Warburton KM. Selection and postoperative care of the living donor. Med Clin 2016;100:599-611.
6. Ratner LE, Ciseck LJ, Moore RG, Cigarroa FG, Kaufman HS, Kavoussi LR. Laparoscopic live donor nephrectomy. Transplantation 1995;60:1047-9.

7. Sozener U. Laparoscopic live donor nephrectomy: single-center experience of 200 consecutive cases. J Laparoendosc Adv Surg Tech A 2021;31:627-31.
8. Cho SJ, Moon HW, Kang SM, Choi SW, Kim KS, Choi YS et al. Evolution of laparoscopic donor nephrectomy techniques and outcomes: a single-center experience with more than 1000 cases. Ann Transplant 2020;25:918189.
9. Abramowicz D, Cochat P, Claas FHJ, Heeman U, Pascual J, Dudlex C et al. European Renal best practice guideline on kidney donor and recipient evaluation and perioperative care. Nephrol Dial Transplant 2015;30:1790-7.
10. Nanidis TG, Antcliffe D, Kokkinos C, Borysiewicz CA, Darzi AW, Tekkis PP et al. Laparoscopic versus open live donor nephrectomy in renal transplantation: a meta-analysis. Ann Surg 2008;247:58-70.
11. Horgan S, Vanuno D, Sileri P, Cicalese L, Benedetti E. Robotic-assisted laparoscopic donor nephrectomy for kidney transplantation. Transplantation 2002;73: 1474-9.
12. Kortram K, Ijzermans JN, Dor FJ. Perioperative events and complications in minimally invasive live donor nephrectomy: a systematic review and meta analysis. Transplantation 2016;100:2264-75.
13. Giacomoni A, Di Sandro S, Lauterio A, Concone G, Buscemi V, Rossetti O et al. Robotic nephrectomy for living donation: surgical technique and literature systematic review. Am J Surg 2016;211:1135-42.
14. Khajeh E, Nikbakhsh R, Ramouz A, Majlesara A, Golriz M, Muller-Stich BP et al. Robot-assisted versus laparoscopic living donor nephrectomy: superior outcomes after completion of the learning curve. J Robot Surg 2023; 17:2513-26.
15. Pelegrin T, Champy CM, Gerbaud F, Miro-Padovani M, Grimbert P, Matignon MB et al. Robotic-assisted laparoscopy living donor nephrectomy: Technique and results of a monocentric retrospective series. Prog Urol 2022; 32:567-76.
16. Brunotte M, Rademacher S, Weber J, Sucher E, Lederer A, Hau HM et al. Robotic-assisted nephrectomy for living kidney donation (RANLD) with use of multiple locking clips or ligatures for renal vascular closure. Ann Transl Med 2020;8:305.