Robotic assisted living donor nephrectomy – the first in the Czech Republic

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Introduction. A kidney transplant is the best method for treating terminal kidney failure. Long-term results of kidney transplants from living donors are significantly better than transplants from dead donors. Living kidney donors are healthy people who undergo a major operation in order to improve the health of another person. Therefore, major emphasis is on safety, low level of invasiveness and a desirable cosmetic effect of the donor nephrectomy. Since 2012, the Department of Urology at the University Hospital in Olomouc has performed 12 kidney harvestings from living donors. The kidney harvesting was conducted using various techniques.
Case Report. The first robotic assisted kidney harvesting in the Czech Republic was performed in June 2022. The donor was a 57-year-old man who donated his kidney to his 32-year-old daughter. The left kidney was evaluated as suitable for kidney harvesting. The operation took 174 min. The kidney's warm ischemia was 145 s. Based on the Clavien Dindo classification, no 2nd degree or high post-operative complications were recorded. The donor's pre-operative glomerular filtration was 1.63 mL/s. Six months post-operation, it went down to 1.19 mL/s. This represents a 27% decrease. The kidney recipient did not require early dialysis. Six months post-operation, the recipient's glomerular filtration was 2.03 mL/s.
Conclusion. In the hands of experienced professionals and transplantation centres, robotic assisted donor nephrectomy is a feasible and safe option for this operation. It not only provides all the advantages of a laparoscopic operation but it also adds other technical improvements and minimizes intraoperative stress on the surgeon. Currently, the global trend is moving towards increasing the ratio of robotic assisted donor nephrectomies.

Key words: living donor nephrectomy, robotic operation, transplantation

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INTRODUCTION

A kidney transplant is the best method for treating terminal kidney failure. Long-term results of kidney transplants from living donors are significantly better compared to transplants from dead donors[1]. Living kidney donors are healthy people, who undergo a major operation in order to improve the health of another person. Therefore, major emphasis is placed on safety, low level of invasiveness and a desirable cosmetic effect of the donor nephrectomy[2]. The kidney harvesting technique has evolved: from an open nephrectomy, to laparoscopic/retroperitoneoscopic (manually) assisted or robotic assisted[3]. A key factor in improving long-term results of a kidney transplant from a living donor is the possibility of timing the transplant as such and executing it even before starting dialysis (= pre-emptive transplant).

The number of patients in the terminal stage of kidney failure waiting for a transplant is constantly increasing, resulting in a disproportion between the number of patients waiting for a transplant and the number of organ donors. The solution is expanding the donor criteria to include donors, who are declared brain dead, donors following cardiac arrest and increasing the number of kidney harvesting from living donors[4].

MATERIALS AND METHODS

Since 2012, the Department of Urology at the University Hospital in Olomouc has performed 12 kidney harvestings from living donors (Table 1). The kidney harvestings were conducted using 4 different techniques – open nephrectomy, manually assisted retroperitoneoscopic nephrectomy, laparoscopic transperitoneal nephrectomy and robotic assisted nephrectomy. A preoperative CT angiography was conducted and renal functions were assessed in each living donor. The kidney with the less effective separated filtration was always taken for harvesting. Another criterium was the absence of renal vessel anomalies. If both donor kidneys were equally functional and no vascular anomalies were found, the left kidney was preferred for harvesting. Kidney harvesting of the left kidney was conducted in 10 cases (83%), taking in to account the results of the separated glomerular filtration of both kidneys and possible vascular anomalies.

Kidney harvesting of the right kidney was chosen in 2 cases (17%). The reason was a reduced glomerular filtration on the right side associated with an anomaly of the main renal vessels on the left side. Kidney donor patients were monitored for one year and kidney recipient patients were monitored for 6 months.

CASE REPORT

The first robotic assisted kidney harvesting in the Czech Republic was performed in June 2022. The donor was a 57-year-old man, who donated his kidney to his 32-year-old daughter. The donor had no comorbidities with a low BMI of 24kg/m^2. According to the CT angiography, there was one kidney artery and one vein on the left side. From the technical point of view, this kidney was deemed more suitable for harvesting.

The position of the patient during operation was on the right side. All four arms of the Davinci Xi robotic system were used. In addition to the camera, scissors, bipolar forceps and prograsp were placed in the other arms. No sealing tool was used. The bed side surgeon had another working port of 12 French. After releasing the kidney from transperitoneal approach and interrupting the ureter at the level of its crossing with the iliac vessels, 1 hilar artery and 1 vein were isolated. Subsequently, the pararectal minilaparotomy was performed, by which the hand of the bed-side surgeon was inserted into the abdominal cavity. After placing 2 hemo-lock clips both on the renal artery and vein at the level of the aorta, both vessels were cut peripherally from the clips with scissors. After the bed side surgeon removed the kidney manually inside the peritoneal cavity. The kidney was prepared for transplantation by lavage with Custodiol solution in crushed ice.

The operation took 174 min and the kidney's warm ischemia was 145 s. The blood loss was 100 mL. The patient was hospitalized for 5 days. The drain was removed on the first post-operative day. Based on the Clavien Dindo classification, no 2nd degree or high post-operative complications were recorded[5]. The donor's glomerular filtration prior to the operation was 1.63 mL/s. Six months post-operation, it went down to 1.19 mL/s. This represents a 27% decrease. The kidney recipient did not require early dialysis. Six months post-operation, the recipient's glomerular filtration was 2.03 mL/s.

RESULTS

The average age of our group of 12 donors was 41.5 years. The youngest donor was 22 years old and the oldest donor was 57 years old. Both sexes were represented in a 7:5 ratio in favour of men. Eight of the twelve harvested kidneys were among blood relatives and 4 were between spouses. None of the donors had any underlying health conditions or the medical conditions were only mild, with no limitation on performance. The average BMI was 30kg/m^2. The donors' average level of serum creatine and glomerular filtration was 70 μmoL/L and 1.73 mL/s.

Table 1. Patients' characteristics (n=12).

Donor pre-operative data	Average
Gender	
Male	7 (59%)
Female	5 (41%)
Age (years)	41.5 (22–57)
Age group (years)	
< 50 y	9 (75%)
50–59 y	3 (25%)
≥ 60 y	0
BMI, kg/m^2	29.8
ASA classification	
1	9 (75%)
2	3 (25%)
Type of nephrectomy	
open	2 (17%)
RSK	4 (33%)
LSK	5 (42%)
RaNE	1 (8%)
Nephrectomy side	
Left	10 (83%)
Right	2 (17%)
CT angiography	
No anomaly	4 (33%)
Anomaly on left side	2 (17%)
Anomaly on right side	5 (42%)
Anomaly on both sides	1 (8%)
Blood relatives	
Yes	8 (67%)
No	4 (33%)
Level of creatinine (μmoL/L)	70
Glomerular filtration (mL/s)	1.73
Operation time (min)	187
Warm ischemia time (s)	192
Blood loss (mL)	141
Number of transfusions	0
Conversion rate (%)	0
Donor post-operative data	
Complications, Clavien-Dindo class.	
Grade 0–1	12 (100%)
Grade 2–5	0
Level of creatinine, after 1 year (μmoL/L)	101
Glomerular filtration, after 1 year (mL/s)	1.18
Post-operative recipient data	
Level of creatinine, after 1 weak (μmoL/L)	187
Glomerular filtration, after 1 weak (mL/s)	1.12
Level of creatinine, after 3 months (μmoL/L)	133
Glomerular filtration, after 3 months) (mL/s)	1.02
Level of creatinine, after 6 months (μmoL/L)	121
Glomerular filtration, after 6 months (mL/s)	1.11

ASA, American society of anesthesiologists; RSK, Retroperitoneoscopic; LSK, Laparoscopic; RaNE, Robotic assited nephrectomy.

The kidney harvesting itself took an average of 187 min and the warm ischemia was 192 s. The average blood loss was 140 mL. No donor required a blood transfusion.

The average length of hospitalization was 6 days. The abdominal drain was usually removed on the first post-operative day. Based on the Clavien Dindo classification, we did not record any 2nd degree or high post-operative complications.

One year after the kidney harvesting, the donors' average level of creatine was 101 μmoL/L and the glomerular filtration fell to 1.18 mL/s, which corresponds to a decrease in the glomerular filtration by 33%.

One week after the transplant, the recipients' average level of serum creatine and glomerular filtration was 187 μmoL/L and 1.12 mL/s. Three months after the transplant, it was 133 μmoL/L and 1.02 mL/s and 6 months after the transplant, it was 121 μmoL/L and 1.11 mL/s. One recipient, a 38-year-old woman, whose 35-year-old sister donated her right kidney by means of an open method, suffered from primary graft rejection. This occurred in the context of thrombotic microangiopathy with a later identified genetic predisposition for atypical haemolytic uraemic syndrome. Another patient, a 29-year-old man suffered from graft rejection within one year. The donor was the patient's 50-year-old mother, whose left kidney was harvested laparoscopically.

In our group, it was confirmed that laparoscopic operations took longer (192 min) than open operations (166 min). In our group, there were no significant differences in the warm ischemia time in individual kidney harvesting techniques. The blood loss was lower for mini-invasive methods, particularly, 120 mL compared to 250 mL in the open methods. Patients, who underwent open kidney harvesting, were hospitalized for 7 days and patients, who underwent kidney harvesting laparoscopically were hospitalized for 5.9 days. If the kidney was harvested using the open method, the recipients' glomerular filtration after one week was 1.0 mL/s, if we do not consider the patient with the primary rejection, in comparison to 1.2 mL/s in patients, who underwent a laparoscopic procedure. The average glomerular filtration values after 6 months were the same as the values one week after the transplant.

DISCUSSION

Studies have shown that kidneys acquired from living donors have better functional results than kidneys acquired from cadaver donors, regardless of the kidney harvesting method[6]. The significantly lower cold ischemia time and the related significant reduction of ischemic damage to the transplanted kidney have a fundamental impact. The transplanted kidney comes from a healthy donor with good functions. A rapid examination of a suitable donor significantly reduces the waiting time for the transplant and ensures that the kidney recipient is also in a better overall condition[1].

The duration of warm ischemia, perioperative complications and speed of recovery are the main factors that influence the choice of the type of donor nephrectomy[2]. The most up to date technique, which was first performed in 2001, was the robotic assisted nephrectomy from a living donor[7]. It is safe and with a very low incidence of post-operative complications. Compared to the open method of kidney harvesting, the advantages of this method are comparable to the laparoscopic kidney harvesting method, i.e., faster post-operative recovery, shorter hospitalization, a smaller operation wound and a lower consumption of analgesics[2]. One study has reported that the return-to-work rate after a laparoscopic donor nephrectomy was 15.9 days in comparison to 51.5 days after the open method[8].

In addition, in comparison to the laparoscopic method, a robotic assisted operation provides more comfort for the surgeon. Its main advantages are evident in obese donors, in donors with multiple kidney arteries as well as right-sided donor nephrectomy, in which it is possible to preserve longer hiller vessels[9]. In contrast, a disadvantage of both the robotic and laparoscopic approaches is a longer operation time and a longer warm ischemia time[1]. The warm ischemia time is most concerning for the functionality of the harvested kidney in the recipient's body. Since this is slightly longer in both the laparoscopic and robotic harvesting compared to open harvesting due to the time needed to extract the kidney from the recipient's body, the reasoning being that a greater warm ischemia duration will lead to a poorer graft function as a result of greater ischemic damage. However, several studies have proved that the longer warm ischemia time in laparoscopic donor nephrectomy does not lead to statistically significant worsening of the graft function long-term, but merely to a slightly delayed onset of functions[10]. Troppmann et al's study further found that a warm ischemia time over 20 min is associated with a higher risk of failure of the harvested kidney[11]. Based on a meta-analyses from 2022, which included 6,398 donor nephrectomies performed using various methods, the warm ischemia time in all donors was under 20 min. Consequently, no relationship between the warm ischemia time and the necessity to perform early dialysis in the graft recipient was recorded[3]. Therefore, a longer warm ischemia time in laparoscopic and robotic donor nephrectomies does not lead to a decrease in the graft function. Therefore, the deciding factors ultimately come down to experience and individual assessment of the technique used by the given transplant centre.

In Spaggiari's study, which included 1,084 robotic assisted donor nephrectomies in one transplant centre over a period of 17 years, the average operation time was 159 min and the average warm ischemia time was 180 s. In comparison to our single robotic kidney harvest, the overall operating time was longer but the warm ischemia time was lower in our kidney harvest. Furthermore, in this study, complications occurred in 20% of the patients during the monitored period of 15 months from the procedure. In 16.5% of the patients, the complications ranked from 1–3 on the Clavien-Dindo classification. In 0.5% of the patients, the complications were 4th degree, particularly pulmonary emboli, retro-peritoneal hematoma and one patient suffered from secondary hemoperitoneum for bleeding from the abdominal vessels, requiring laparoscopic re-evaluation, which resulted in a ligature of the bleeding vessels. One patient died (0.1%) after robotic donor nephrectomy. The cause was peritonitis of unknown

origin. The autopsy identified a previously unidentified intestinal injury[12]. In another study that retrospectively analyses 118 robotic assisted kidney harvestings, there was no conversion during the procedure. Only 1.7% of the recipients had a delayed onset of the graft function, requiring early dialysis. The recipient's average glomerular filtration one year after the transplant was 1.02 mL/s or 61 mL/min[13].

Harvesting a kidney is a very psychologically taxing procedure for the kidney donor, the kidney recipient and the surgeon because the kidney is harvested from a completely healthy individual. For this reason, donor nephrectomy safety is paramount. Thus, a technique with the lowest mortality rate, without decreasing the functionality of the donated kidney should be used. Currently, there is a global tendency to do this procedure more carefully and laparoscopically. In addition, the currently introduced robotic assisted kidney harvesting is now available[1]. Donating a kidney does not have any direct impact on decreasing the donor's life expectancy[14].

However, there are distinct drawbacks to donor nephrectomy. The mortality of donor nephrectomy is 0.03%. In addition, 2–20% of donors suffer from long-term pain. In 70% of cases, patients have a compromised glomerular filtration and arterial hypertension develops in 5–30% of cases. Generally, following an initial decrease, the glomerular filtration remains stable, the systolic capacity of blow flow into the kidneys rises and the solitary kidney enlarges. Approximately 70% of people have normal GF values after donating a kidney[15].

CONCLUSION

A kidney can be harvested from a living donor using various surgical techniques. In choosing a techniques, minimizing invasiveness while maintaining the lowest possible intraoperative risk and the donor's speedy recovery, all while achieving the best long-term function of the recipient's graft.

In the hands of experienced professionals, robotic assisted donor nephrectomy is a safe option. It provides all the advantages of a laparoscopic operation and adds other technical improvements. Currently, the global trend is towards increasing the ratio of robotic assisted donor nephrectomies.

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