ORIGINAL RESEARCH

Clinical Outcomes of Removing the Better Functioning Kidney During Laparoscopic Donor Nephrectomy: A Retrospective Five-year Single-Center Study

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Objective: The primordial principle in living kidney donation is leaving the better functioning kidney (BFK) with the donor. However, when laparoscopic donor nephrectomy (LDN) is utilized, certain conditions may warrant removing the BFK. These include lesser complex vasculature, renal calculi, or left-sidedness. Reported here are the long-term outcomes of removing the BFK among living donors.

Methods: Chart review was done on all donor nephrectomy patients over a five-year period. Patients whose BFK were removed via LDN were identified. Clinical indications, patient demographics, perioperative and postoperative outcomes were summarized. Creatinine and eGFR at one-day, one-month and one-year follow-up were used to determine renal functional outcomes.

Results: Between January 2011 to December 2015, 810 donor nephrectomies were performed: 366 (45.2%) and 444 (54.8%) had open donor nephrectomy and LDN, respectively. BFK was removed in 26 (5.8%) in the LDN and none in the open group. Mean age was 28.9$\pm$7.5 (18-49), with a male to female ratio of 4:1. The clinical indications were less complex vasculature in 18 (69%), left-sided BFK in 7 (27%) and renal calculi in 1 (3.8%). The mean operative time was 173 $\pm$25 (130–272) minutes, with a mean blood loss of 111 $\pm$96 (50-200)cc. The mean length of stay was 3.0$\pm$0.2 (2.8-4) days. Grade 1 complications were seen in 5 (19%) patients. There was no mortality. The eGFR after 1 year is 79.4$\pm$14.1 (54-91) cc/min.

Conclusion: Removing the BFK during LDN does not impact negatively on the safety and renal functional outcomes of living kidney donors.

Key words: better functioning kidney, laparoscopic donor nephrectomy

Introduction

In living kidney donation, a better functioning kidney (BFK) is defined as having a disparate differential renal function of more than 10% compared to the contralateral kidney.[1,2] In this context, the foremost guiding principle in choosing the laterality for living kidney donation, which is stronghold of organ donor advocacy, hinges on leaving the BFK with the donor. The reason for this is the need to maximize residual renal function while limiting the risks of progression to chronic kidney disease requiring renal replacement therapy.

However, this decision to leave the BFK is not always easy especially when laparoscopic donor nephrectomy (LDN) is utilized to obtain the renal allograft. In LDN, complex vascular anomalies may portend to a difficult and even risky, renal allograft procurement. Sufficient margins needed for safe application of clips should be balanced against the adequacy of the length of the vessels

for allograft implantation. Further, when the transplant surgeon is dealing with multiple or short vasculature, additional bench work may be needed which tend to increase warm and cold ischemia times. Technical problems during allograft implantation also may lead to vascular kinks and thrombosis. These issues need to be sorted out in order not to compromise either the quality of the allograft nor the safety of the healthy living donor. In addition to vascular issues, when anatomical aberrations such as renal calculi are present in the BFK, leaving them with the donor may be detrimental to their renal function in the future.

A unique situation arises when a donor explicitly requests a laparoscopic method of kidney retrieval. In this situation, the surgeon may be compelled to opt to remove a left-sided BFK because he may find it more easily and safely obtained with laparoscopy as compared to the opposite side. Such is the case when surgeons lack the experience and expertise in doing a right-sided LDN.

One potential solution to all these predicaments is to disqualify such a donor candidate, prompting a search for an alternative donor. However, in extreme scenarios, the search for a more optimal candidate seems endless. Another option is to offer open donor nephrectomy, if the patient agrees. However, given all the disincentives that open donor nephrectomy brings such as lengthy unsightly scars, the consent for open surgery remains challenging. Ultimately, it may be judicious to just procure the BFK in order to proceed with renal transplantation. The clinical question however, is whether preference for removing the BFK will affect the clinical outcome of these donors. There are currently no reports determining the postoperative and renal functional outcomes of living kidney donors after procurement of the BFK. The aim of the present study is to determine if removing the better functioning kidney from a living kidney donor would be detrimental to his long-term renal function.

Methods

This is a descriptive study which has been approved by the Hospital Ethics Review Board, in accordance with the Helsinki Declaration of 1975, as revised in 1983. A chart review was done on all living kidney donors who underwent donor nephrectomy from January 2011 to December 2015. All donors whose BFK were removed were identified and subjected to data analysis. Data were gathered from the patient medical records and the NKTI Laboratory Communication System (MedSys). Patients whose BFK were removed, based on the preoperative differential renal function, were identified and their data were summarized. All patient identifiers were excluded to maintain utmost confidentiality. Data included the following: 1) Clinical demographics of donors (age, gender, BMI, ASA risk, preoperative GFR), 2) Clinical indications for removing the BFK (less complex vasculature, left-sided BFK, presence of renal calculi), 3) CT angiographic features of patients with complex vasculature, 4) Intraoperative parameters (operative time, estimated blood loss, warm ischemia time, conversion to open), 4) Postoperative parameters (length of hospital stay, transfusion requirements, reoperation rate, complications), 5) Postoperative renal function (serum creatinine and eGFR) (one-day, one-month, one-year).

Frequencies, means and percentages were used to describe the different clinical parameters Complications were analyzed using the modified Dindo-Clavien Classification.[3]

Results

A total of 810 patients underwent donor nephrectomy from January 2011 to December 2015. There were 366 (45.2%) who underwent open donor nephrectomy (ODN) and 444 (54.8%) who were subjected to laparoscopic donor nephrectomy (LDN).

Twenty-six out of 444 (5.8%) in the LDN group had the BFK removed while there was none among the ODN group. Therefore, only these 26 patients subjected to laparoscopic donor nephrectomy were included in the data analysis. All other patients whose lesser functioning kidneys procured either by laparoscopy or open were excluded from the study.

The demographic data of BFK patients are summarized in Table 1. The mean age is 28.9$\pm$7.5

(18-49), with a male to female ratio is 4:1. The mean BMI is 24.8±3.4 (19.3-31.3). The mean ASA score is 1.15±0.37 (1-2). The mean difference in glomerular filtration rate (GFR) between the two kidneys is 11.33±1.86. (R:10 to 16)%. The clinical indications for removing the better functioning kidney include: less complex vasculature (69%), left-sided BFK (27%), presence of renal calculi (3.8%) (Table 2). The mean operative time is at 173 ± 25 (130–272) minutes, mean estimated blood loss at 111 ± 96 (50-200) ml., mean length of hospital stay at 3±0.2 (2.8-4) days, mean ischemia time at 4±1 (3-9) minutes (Table 3). The mean creatinine at post day 1 is 1.30±0.32 (0.2-1.8) mg/dL, at 1 week post-op is 1.29±0.29 (0.3-1.6), 1 month post op is 1.21±0.35 (0.3-1.6) and 1 year post op is 1.15±0.24 (0.7-1.5) (Table 4). At 1 year, none of the donors has developed chronic kidney disease stage 3 to 5. There was no evidence of proteinuria. The average estimated GFR at one year is 79.4± 14.1 (54-91) mL/min/1.73m^2. There were five Grade 1 complications, i.e. fever experienced on post-operative day 1-2 which were managed conservatively. There was no mortality.

Table 1. Clinical characteristics of living donors whose BFKs were removed during LDN.

Clinical characteristics	Mean ± SD (Range)
Age (years)	28.9 ± 7.5 (18-49)
Male to Female Ratio	4:1
BMI (mg/m^2)	24.8 ± 3.4 (19.3-31.3)
ASA risk	1.15 ± 0.37 (1-2)

Table 2. Summary of clinical indications for removing the BFK via LDN.

Clinical indications	n (%)
Less complex renal vasculature	18 (69%)
Left-sided BFK	7 (27%)
Presence of renal calculi	1 (3.8%)

Table 3. Intraoperative parameters of donors whose BFKs were removed via LDN.

Clinical parameters	Mean ± SD (Range)
Operative time (minutes)	176 ± 25 (130 – 272)
Estimated blood loss (ml)	111 ± 96 (50-200)
Length of hospital stay (days)	3 ± 0.2 (2.8-4)
Warm ischemia time (minutes)	4 ± 1 (3-9)

Discussion

Living kidney donor transplantation (LKDT) provides longer and superior long-term allograft survival compared to its deceased donor counterpart.[4] In fact, the worst HLA-matched living kidney allograft still fares better compared to a completely HLA-matched deceased donor allograft.

However, while LKDT improves the lives of those with end-stage renal disease, several health risks to the donor need to be considered. For one, the surgery of living donor nephrectomy is being done on a healthy individual. Therefore, the margin of error should be minimized or even close to none at all. There are risks that are inherent to the surgical procedure itself such as bleeding, infection, and even mortality. The other concerns include unsightly and painful incisions in ODN, which may affect day-to-day activities and the performance of one's profession. Another relevant issue includes the development of chronic kidney disease which may lead to renal failure.

Laparoscopic live donor nephrectomy (LDN) was introduced in 1993 by Ratner, et al. in order to remove all the disincentives that are experienced

Table 4. Follow-up serum creatinine and eGFR of living donors whose BFKs were removed.

Follow-up period	Mean creatinine (mg/dL)	eGFR (mL/min/1.73m^2)
1 day	1.32 ± 0.24 (0.9-1.8)	67.2 ± 16.4 (46-107)
1 week	1.31 ± 0.22 (0.8-1.6)	67.9 ± 16.2 (46-108)
1 month	1.24 ± 0.26 (0.8-1.6)	72.7 ± 18.7 (46-108)
1 year	1.15 ± 0.24 (0.7-1.5)	79.4 ± 14.1 (54-91)

by the donor in ODN.[5] It is now considered the preferred method of obtaining renal allografts among living kidney donors. Long-term studies showed that LDN offers comparable donor safety profile, a shorter length of hospital stay, and an equivalent allograft survival compared to open live donor nephrectomy.[6,7,8,9,10]

Serious technical challenges, however, are encountered when LDN is done on the right or in kidneys with multiple vasculature. Only high volume centers can recommend its application to these situations routinely.[15] When done by experienced laparoscopic surgeons, LDN has been shown to be comparable in allograft outcome even in multiple renal arteries[6,7,8] and right-sided nephrectomy.[11,12,13] Even if this was the case, some surgeons however, prefer not to do right-sided LDN because of the challenges involved when dissecting the renal vein off the inferior vena cava. The transplant surgeon's willingness to accept an allograft which will require further bench work prior to allograft implantation also influences the choice of laterality of donation.

The left side is usually preferred in living kidney donation because of the longer renal vein. This is particularly relevant when LDN is utilized during the allograft procurement because it is impossible to lengthen the vein on the right with a vena caval cuff, in a manner similar to ODN. Potential complications may lead to higher graft-failure, renal vein thrombosis, more back-table reconstruction and increased operative time.[13,14,15,16,17] Recently, the authors reported our experience demonstrating that, in the hands of experienced laparoscopic surgeons, equivalent donor and allograft outcomes may be achieved in LDN, regardless of laterality of donation.[12]

A serious risk to the donor is the potential for developing end-stage renal disease. One study reported that the risk of developing ESRD was, in relative terms, 11-fold higher in living kidney donors compared to healthy non-donors.[13] However, a study done by Ibrahim, et al. showed that the survival and risk of ESRD in carefully screened kidney donors appears similar to those in the general population (180 cases per million person-years in donors vs. 268 per million person-years in the general population).[14] The authors agree with this observation. The progression to critical chronic kidney disease stages 4 or 5 is a result of multifactorial causes which may not necessarily relate to the solitary functioning kidney status alone but to other risk factors such as late-onset diabetes mellitus, hypertension, dyslipidemia and obesity, which may all contribute to a patient's metabolic syndrome.

To the surgeon harvesting the kidney therefore, much effort should be made in preserving the BFK of the altruistic donor. In selecting the kidney to be removed, there are three factors that are considered: the glomerular filtration rate (GFR), presence of kidney pathology (e.g. stone, cyst) and vascular anomalies (e.g. multiple, stenosis). Some centers would prefer removing the left kidney because of the longer left renal vein regardless of GFR or kidney pathology or vascular anatomy.[18,19] Some centers would prioritize leaving the BFK to the donor and harvest the lesser functioning kidney.[1,2,20,21,22] There are certain instances however when the BFK may need to be procured when there is a co-existent renal pathology (such as a small renal cortical cyst or renal calculi) or a lesser complicated vasculature (e.g. single artery and single vein).[1,2,20,21,22] Whenever there is a question of procuring the BFK because of these anatomical issues, the British Transplantation Society recommends a multidisciplinary approach in deciding the side of the kidney to be removed.[23] In NKTI, when such critical issues are present, a multidisciplinary team [composed of the transplant surgeon, nephrologist (donor advocate) and urologist) is convened to help decide the laterality of donation and modality of procurement (ODN vs. LDN.)

In the present study, eighteen (69%,) donors had anomalous bilateral renal vasculature, with the BFK having less complexity. The other 8 (31%) were all left-sided BFKs with normal renal vasculature. Of these eight, 1 (3.8%) had a 0.2cm calculus on the inferior calyx. The less complex vasculature, left-sided laterality and calculus disease in BFKs prompted their removal for donation. The authors considered the option of offering these patients with left-sided BFKs to undergo ODN so that the lesser functioning kidney may be removed. However, after a lengthy discussion of the advantages and disadvantages of ODN vs. LDN, as well as the repercussions of removing the BFK, these donors

insisted to having an LDN done on the BFK. Indeed, there are donors who would prefer LDN over ODN despite having the BFK removed. In a study by Kuo, 47% of live donors donated solely because of the LDN procedure.[24]

Scheitzer, et al. established an increase in the donation rate after the introduction of LDN.[25] Majority of living donors prefer to undergo LDN, thus limiting the option of surgeons to recommend ODN in challenging situations. Balancing therefore the risks of surgery and the need to perform the procedure laparoscopically, the lesser functioning kidney with challenging anatomical variations is left with the patient and the BFK is chosen for donation. While it has been established that right-sided LDN can be performed safely and with equivalent donor and recipient outcomes compared to the left-side, right-sided LDN is still underutilized in NKTI.[13] The reason for this is that there are still laparoscopic surgeons in the center who preferentially avoid doing right-sided LDNs because of its technical challenges.

Several studies commonly share the recommendation of preferentially preserving the BFK.[1,2,20,21,22] which is defined as having a differential GFR >10% as measured by DTPA (Diethylene Triamene Pentacetic acid) compared to the opposite side.[1,2] There are instances however when the BFK is chosen because of a co-existent pathology (e.g. cyst, stone) or has a lesser complicated vasculature (e.g. single artery and single vein, longer vessel length).[1,2,20,21,22]

In regular donors, percentages are not as important as the absolute GFR. In terms of absolute values, the recommended residual GFR should be at least 40cc/min. Looking at present data, none of the patients with BFK removed had residual GFR of less than 40cc/min. This explains why after 1 year, the eGFR was at acceptable level at 1 year follow-up for all patients. This suggests that the absolute residual renal function is more important than the estimated percentages of renal function that each kidney bears, when determining the risk of progression to critical chronic renal disease.

The authors agree that when making a choice as to the laterality of kidney donation, the BFK should be left with the patient. In exceptional cases however, when removing the BFK becomes an important clinical decision, a multidisciplinary discussion, which includes the transplant candidate, the potential kidney donor and the entire transplant team should be conducted to ensure not only a high quality renal allograft but equally important, a safe surgery and long-term renal function and survival for the kidney donor.

There is inherent selection bias in a donor nephrectomy study, because these patients cannot be randomized to a specific treatment modality (ODN vs. LDN). A match-paired analysis comparing the better and lesser functioning kidneys which are procured laparoscopically may appear to be a better design to determine differences in long term outcomes for the living kidney donor. However, this is fraught with a selection bias from the outset because the indications for taking either side is based on several principles including the health and safety of the donor, the quality of the allograft and the technical considerations of allograft implantation. Further, the surgeon experience plays an important role in determining whether or not LDN may be applied to very challenging situations such as those with complex and multiple vasculature. The retrospective nature of this study also limits the sample size, the number of operators (multiple surgeons) and the authors' ability to retrieve clinical data after one year. The renal function beyond 1 year is out of the scope of this research and the authors recommend studies that would look beyond one-year renal function of donors.

Ideally, the total warm ischemia time, which is the time from renal arterial occlusion in the donor to reperfusion after allograft implantation, should be included in the study. The authors only included initial warm ischemia time (defined as time of renal arterial occlusion to placement in the cold bath.) By focusing on total warm ischemia time, we can further evaluate its effects on renal allograft and as well as long-term recipient outcomes. However, all of these data are beyond the scope of this study.

Conclusion

Laparoscopic retrieval of BFKs among living kidney donors provide a high safety profile which does not have a negative impact on the long-term

renal function. More experience with right-sided LDN may potentially decrease the number of donors having their left-sided BFKs removed during laparoscopic donation.

Disclosure

There are no conflicts of interests. The authors have nothing to declare.

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