Recipient outcomes in total laparoscopic live donor nephrectomy with multiple renal vessels

John Fitzpatrick, Jakub Chmelo, Arjun Nambiar, Oliver Fuge, Toby Page, Gourab Sen, Naeem Soomro, David Rix, Alistair Rogers, David Talbot, Rajan Veeratterapillay
Department of Urology, Freeman Hospital, Institute of Transplantation, Freeman Hospital, Newcastle-Upon-Tyne, United Kingdom

Abstract

Introduction: In kidney transplantation, total laparoscopic live donor nephrectomy (TLLDN) in the presence of multiple renal arteries (MRA) is technically challenging and has traditionally been associated with higher complication rates. We report our experience of using MRA grafts procured by TLLDN.

Materials and Methods: Patients undergoing TLLDN at our center (2004–2014) was identified from a prospectively maintained database and divided into single renal arteries (SRA) or MRA groups. Recipient perioperative parameters, postoperative complications, and long-term graft survival were analyzed.

Results: Of 465 patients, 106 had MRA and 359 had an SRA. There were six vascular complications in the SRA group and two in the MRA group (1.7% vs. 1.8%). There were eight ureteric complications requiring intervention in the SRA group compared to three in the MRA group (4% vs. 3%; \( P = 0.45 \)). Acute rejection was observed in 12% of the SRA group compared to 9% in the MRA group (\( P = 0.23 \)). One-, 5- and 10-year graft survivals were 98.2%, 91.3%, and 89.8% in the MRA group versus 98.0%, 90.4%, and 77.5% in the SRA group (log-rank \( P = 0.13 \)).

Conclusion: The use of MRA grafts procured by TLLDN has comparable complication rates to SRA grafts and should not preclude selection for renal transplantation.

Keywords: Graft survival, kidney transplantation, laparoscopic nephrectomy, living donors, renal artery

INTRODUCTION

In the majority of patients with end-stage renal failure, renal transplantation remains the preferred treatment option due to improved quality of life and overall survival.[1] As a result, the pressure to fulfill the need for donor grafts is growing. In order to meet this demand, donor criteria have now evolved to include grafts with multiple renal arteries (MRA), made possible in part by advances in laparoscopic and surgical techniques. Conventionally, MRA grafts were not considered to be suitable due to reservations regarding higher complication rates. Some studies have reported increased incidences of warm ischemic time (WIT), delayed graft function (DGF), vascular and urological complications with MRA grafts.[2-9] Despite this, the current literature is still inconclusive and when comparing recipient outcomes from grafts with single renal arteries (SRA) and those with MRA, there does not appear to be a significant difference in long-term graft survival.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Fitzpatrick J, Chmelo J, Nambiar A, Fuge O, Page T, Sen G, et al. Recipient outcomes in total laparoscopic live donor nephrectomy with multiple renal vessels. Urol Ann 2020;12:266-70.
survival.\textsuperscript{[10–23]} With up to 35\% of donors having MRA, the ability to use these grafts for transplantation improves the donor pool greatly and helps to address transplant waiting times.\textsuperscript{[24]} It is not unsurprising therefore that MRA grafts are being used more frequently, although perhaps not more favorably, with encouraging results.

We present a tertiary center experience of recipient outcomes using both SRA and MRA grafts procured by total laparoscopic live donor nephrectomy (TLLDN).

**MATERIALS AND METHODS**

From July 2004 to December 2014, 465 patients with complete records undergoing TLLDN renal transplantation at our center were identified from a prospectively maintained departmental database. All donors were either living related or living unrelated.

**Graft harvest and vascular reconstruction/transplantation**

The preoperative vascular anatomy of the donor grafts was delineated using computed tomography (CT) angiography, and split renal function was evaluated by diuretic renography. Grafts were harvested by a total laparoscopic approach (transperitoneal, 3- or 4-port) with extraction through a Pfannenstiel incision. There were no conversions to an open procedure. Left-sided grafts were preferentially procured due to a longer renal vein and the presence of MRA in a left-sided graft did not preclude its selection for transplantation. For patients with MRA, vascular reconstruction was undertaken on the back-table during the cold ischemic phase using either end-to-side, side-to-side, or a combination of the two anastomotic techniques. The standard open extraperitoneal approach was adopted for all recipient procedures. The iliac vessels, aorta or inferior vena cava were used for vascular anastomosis, depending on recipient size. For the ureteric anastomosis, an extravesical ureteroneocystostomy was performed over a ureteric stent.

**Postoperative course and follow-up**

Following graft implantation, patients underwent daily monitoring of serum creatinine, electrolytes, and hemoglobin. A Doppler ultrasound was performed within 24 h to evaluate graft vascular flow. Graft biopsies were taken in cases of clinically unexplained graft impairment.

The postoperative complications analyzed were vascular, urological, and acute rejection. All episodes of acute rejection were biopsy proven. Postoperative complications were recorded and stratified according to the Clavien-Dindo classification.

At discharge, patients were generally followed weekly for 3 months, monthly for 6 months, and every 3 months with urine analysis, serum creatinine level, full blood count, and immunosuppression drug level.

**Statistical analysis**

As described previously, patients were classified into either the SRA or MRA group. Parameters used to compare the two groups included patient demographics, site of vascular anastomosis, and ischemic times (primary and secondary WIT, cold ischemic time [CIT]). Primary WIT was defined as the time from cross-clamping of the graft during TLLDN to commencement of cold perfusion, CIT as the graft time spent in cold perfusate and secondary WIT as the time from removal of the graft from cold perfusate until reperfusion.

In addition, the incidence of postoperative complications was compared between the groups. The Pearson, Chi-square, and Student’s \( t \)-tests were used to determine the statistical significance of any differences. Graft survival rates were compared among the two groups using Kaplan–Meier analysis and the log-rank test. \( P < 0.05 \) was considered statistically significant.

**RESULTS**

During the study, 465 patients were included. In our series, 23\% of patients had MRA-91 patients with double arteries, 12 patients with triple arteries, and 3 patients with four renal arteries. Both groups were reasonably matched with regard to demographic data [Table 1].

**Intraoperative differences**

Patients with MRA had a statistically higher CIT (122 min vs. 62 min, \( P < 0.05 \)) which was required for graft harvest and vascular reconstruction. The preoperative vascular anatomy of the donor grafts was delineated using computed tomography (CT) angiography, and split renal function was evaluated by diuretic renography. Grafts were harvested by a total laparoscopic approach (transperitoneal, 3- or 4-port) with extraction through a Pfannenstiel incision. There were no conversions to an open procedure. Left-sided grafts were preferentially procured due to a longer renal vein and the presence of MRA in a left-sided graft did not preclude its selection for transplantation. For patients with MRA, vascular reconstruction was undertaken on the back-table during the cold ischemic phase using either end-to-side, side-to-side, or a combination of the two anastomotic techniques. The standard open extraperitoneal approach was adopted for all recipient procedures. The iliac vessels, aorta or inferior vena cava were used for vascular anastomosis, depending on recipient size. For the ureteric anastomosis, an extravesical ureteroneocystostomy was performed over a ureteric stent.

**Postoperative course and follow-up**

Following graft implantation, patients underwent daily monitoring of serum creatinine, electrolytes, and hemoglobin. A Doppler ultrasound was performed within 24 h to evaluate graft vascular flow. Graft biopsies were taken in cases of clinically unexplained graft impairment.

The postoperative complications analyzed were vascular, urological, and acute rejection. All episodes of acute rejection were biopsy proven. Postoperative complications were recorded and stratified according to the Clavien-Dindo classification.

At discharge, patients were generally followed weekly for 3 months, monthly for 6 months, and every 3 months with urine analysis, serum creatinine level, full blood count, and immunosuppression drug level.

**Statistical analysis**

As described previously, patients were classified into either the SRA or MRA group. Parameters used to compare the two groups included patient demographics, site of vascular anastomosis, and ischemic times (primary and secondary WIT, cold ischemic time [CIT]). Primary WIT was defined as the time from cross-clamping of the graft during TLLDN to commencement of cold perfusion, CIT as the graft time spent in cold perfusate and secondary WIT as the time from removal of the graft from cold perfusate until reperfusion.

In addition, the incidence of postoperative complications was compared between the groups. The Pearson, Chi-square, and Student’s \( t \)-tests were used to determine the statistical significance of any differences. Graft survival rates were compared among the two groups using Kaplan–Meier analysis and the log-rank test. \( P < 0.05 \) was considered statistically significant.

**RESULTS**

During the study, 465 patients were included. In our series, 23\% of patients had MRA-91 patients with double arteries, 12 patients with triple arteries, and 3 patients with four renal arteries. Both groups were reasonably matched with regard to demographic data [Table 1].

**Intraoperative differences**

Patients with MRA had a statistically higher CIT (122 min vs. 62 min, \( P < 0.05 \)) which was required for graft harvest and vascular reconstruction. The preoperative vascular anatomy of the donor grafts was delineated using computed tomography (CT) angiography, and split renal function was evaluated by diuretic renography. Grafts were harvested by a total laparoscopic approach (transperitoneal, 3- or 4-port) with extraction through a Pfannenstiel incision. There were no conversions to an open procedure. Left-sided grafts were preferentially procured due to a longer renal vein and the presence of MRA in a left-sided graft did not preclude its selection for transplantation. For patients with MRA, vascular reconstruction was undertaken on the back-table during the cold ischemic phase using either end-to-side, side-to-side, or a combination of the two anastomotic techniques. The standard open extraperitoneal approach was adopted for all recipient procedures. The iliac vessels, aorta or inferior vena cava were used for vascular anastomosis, depending on recipient size. For the ureteric anastomosis, an extravesical ureteroneocystostomy was performed over a ureteric stent.

**Postoperative course and follow-up**

Following graft implantation, patients underwent daily monitoring of serum creatinine, electrolytes, and hemoglobin. A Doppler ultrasound was performed within 24 h to evaluate graft vascular flow. Graft biopsies were taken in cases of clinically unexplained graft impairment.

The postoperative complications analyzed were vascular, urological, and acute rejection. All episodes of acute rejection were biopsy proven. Postoperative complications were recorded and stratified according to the Clavien-Dindo classification.
back-table reconstruction. Techniques used to reconstruct the arteries were side-to-side anastomosis (56%), end-to-side anastomosis (26%), sacrificing a small polar artery (3%), or a combination of these techniques (15%). The mean estimated blood loss was also higher in the MRA group compared to the SRA group (362 vs. 292 ml, \( P < 0.05 \)).

Postoperative complications
There were six vascular complications (1.7%) in the SRA group; two graft artery stenoses, one arterial intimal dissection, and three laparotomies for postoperative anastomotic bleeding, one of which resulted in graft loss. There were two vascular complications (1.8%) in the MRA group which were both laparotomies for postoperative anastomotic bleeding. There were eight ureteric complications (4%) requiring subsequent intervention (reimplantation or long-term ureteric stenting) in the SRA group compared to three (3%) in the MRA group. Acute rejection following renal transplant was seen in 14% of the SRA group compared to 11% in the MRA group. Overall, Clavien III/IV complications were noted in 6% of the SRA group and 7% of the MRA group [Table 1].

Graft function
About 94% of patients in the MRA group had functioning grafts at a median time follow-up of 50 months. During the study, there were 8 graft failures in the MRA group and 35 in the SRA group. One year, 5-year and 10-year graft survival were 98.2%, 91.3%, and 89.8% in the MRA group versus 98.0%, 90.4%, and 77.5% in the SRA group. Kaplan–Meier analysis showed no statistically significant difference that was noted in our cohort appear to affect overall long-term graft survival. The only other significant difference that was noted in our cohort was that transplanting MRA grafts is a safe procedure with no difference in long-term outcomes.\(^{[10-22]}\) This has been supported by a large meta-analysis which showed comparable long-term outcomes for graft and patient survival.\(^{[23]}\) Some studies, however, have suggested higher recipient postoperative complication rates with MRA grafts.\(^{[24]}\)

Overall, the current literature [Table 2] would support that transplanting MRA grafts is a safe procedure with no difference in long-term outcomes.\(^{[10-22]}\) This has been supported by a large meta-analysis which showed comparable long-term outcomes for graft and patient survival.\(^{[23]}\)

**DISCUSSION**
In our institution, left-sided donor grafts are preferred as the longer renal vein makes vascular anastomosis technically easier and has also been shown to decrease operating time.\(^{[22]}\) The practice of selecting left-sided grafts is not uncommon and has been adopted by other institutions.\(^{[20]}\)

### Table 2: Literature comparison summary for multiple renal artery grafts

| Author/year | Cohort (n) | Procedure | Left:right grafts (% left side) | SRA:MRA (% MRA) | WIT (n) | DGF | Vasc | Uro | 1-year graft survival (%) (single:multiple) |
|-------------|------------|-----------|--------------------------------|-----------------|--------|-----|------|-----|------------------------------------------|
| Troppmann 2001 | 78 | LDN | 79:0 (100) | 57:21 (27) | 57.21 | No | No | No | 97:95 |
| Hsu 2003 | 353 | LDN | 33:20 (94) | 277:76 (22) | MRA | No | No | No | 95:93 |
| Carter 2005 | 361 | LDN | 31:49 (86) | 312:49 (14) | MRA | No | No | MRA | ... |
| Desai 2007 | 303 | LDN | ... | 245:58 (19) | MRA | ... | ... | ... | 94:93 |
| Paragi 2011 | 976 | LDN/HAL | 846:27 (97) | 799:177 (18) | MRA | No | No | MRA | ... |
| Tyson 2011 | 510 | LDN | ... | 393:117 (23) | MRA | No | No | MRA | ... |
| Meyer 2012 | 130 | LDN/HAL | 97:33 (75) | 108:22 (17) | MRA | No | No | MRA | ... |
| Chedid 2013 | 1134 | HAL | 865:269 (76) | 924:210 (19) | ... | ... | ... | No | 95:96 |
| Cooper 2013 | 997 | LDN/HAL | 968:29 (97) | 742:255 (26) | MRA | No | No | MRA | ... |
| Bandin Musa 2016 | 165 | HAL | 160:5 (97) | 134:31 (19) | MRA | No | ... | ... | ... |

LDN: Laparoscopic donor nephrectomy, HAL: Hand-assisted laparoscopic, SRA: Single renal artery, MRA: Multiple renal arteries, WIT: Warm ischaemic time, DGF: Delayed graft function, Vasc: Vascular complications, Uro: Urological complications, ↑: Increased
was increased estimated blood loss with MRA, although this has been commented on in other papers.[9] DGF, although not included in our study, is another variable that has been analyzed with MRA grafts procured by LLDN; some studies have demonstrated a higher incidence with MRA grafts although with no difference in graft survival at 1 year when compared to SRA grafts.[5,17,21] There has been some concern regarding vascular complications with MRA grafts, most commonly arterial stenosis and thrombosis. This has however been demonstrated in studies whose cohorts have included deceased donors and open donor nephrectomies.[8,9] When looking at vascular complications in studies that have included only LLDN, an increased incidence is not reported.[5,8,13,14,17,20,21,29] This is comparable to our study; out of six vascular complications, the majority of which were hemorrhagic, only two arterial stenoses were observed, both of which were in the SRA group. We did not report any arterial stenosis or thrombosis in the MRA group and there was no significant difference in vascular complications between MRA and SRA grafts. Concern around the transplantation of MRA grafts has also focused on an increased reported incidence of urological complications in the recipient. Both Carter et al. and Cooper et al. demonstrated a statistically significant increase in urological complications in MRA graft recipients from LLDN than with SRA graft recipients.[5,3] In our study, however, we did not find this to be the case with no statistical difference in urological complications between MRA and SRA grafts.

Despite the potential postoperative complications associated with transplanting MRA grafts, the overall long-term outcomes seem to be encouraging. Comparable 1-year graft survival rates in recipients have been reported when comparing MRA and SRA grafts procured by LLDN.[5,8,13,14,17,20,21,29] We also report good 1-year and long-term graft survival rates in MRA grafts with no statistically significant difference to SRA grafts.

**CONCLUSION**

The use of MRA grafts procured from TLLDN in renal transplantation is a safe procedure with comparable complication rates to SRA grafts. There is no statistical difference in long-term graft survival between MRA and SRA grafts. The presence of MRA in a donor graft should not preclude its selection for renal transplantation.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Tonelli M, Wiece N, Knoll G, Bello A, Browne S, Jadhav D, et al. Systematic review: Kidney transplantation compared with dialysis in clinically relevant outcomes. Am J Transplant 2011;11:2093-109.
2. Benedetti E, Troppmann C, Gillingham K, Sutherland DE, Payne WD, Dunn DL, et al. Short- and long-term outcomes of kidney transplants with multiple renal arteries. Ann Surg 1995;221:406-14.
3. Carter JT, Freise CE, McTaggart RA, Mahaney HD, Kang SM, Chan SH, et al. Laparoscopic procurement of kidneys with multiple renal arteries. Ann Surg 2011;343:2423-5.
4. Cooper M, Kramer A, Nogueira JM, Phelan M. Recipient outcomes of dual and multiple renal arteries following 1000 consecutive laparoscopic donor nephrectomies at a single institution. Clin Transplant 2013;27:261-6.
5. Desai MR, Ganpule AP, Gupta R, Thimmegowda M. Outcome of renal transplantation with multiple versus single renal arteries after laparoscopic live donor nephrectomy: A comparative study. Urology 2007;69:824-7.
6. Ghazanfar A, Tavakoli A, Zaki MR, Pararajasingam R, Campbell T, Parrott NR, et al. The outcomes of living donor renal transplants with multiple renal arteries: A large cohort study with a mean follow-up period of 10 years. Transplant Proc 2010;42:1654-8.
7. Kamali K, Abbas MA, Ani A, Zargar MA, Shahrokh H. Renal transplantation in allografts with multiple versus single renal arteries. Saudi J Kidney Dis Transpl 2013;24:246-50.
8. Laoud J, Bretagnol A, Fabre E, Halimi JM, Al‑Najjar A, Boutin JM, et al. Kidney transplant with multiple renal artery grafts from deceased donors: Are long‑term graft and patient survival compromised? Prog Transplant 2012;22:102-9.
9. Ali‑El‑Dein B, Osman Y, Shoikeir AA, Shehah El‑Dein AB, Sheashaa H, Ghoneim MA. Multiple arteries in live donor renal transplantation: Surgical aspects and outcomes. J Urol 2003;169:2013-7.
10. Ashraf HS, Hussain I, Siddiqui AA, Ibrahim MN, Khan MU. The outcome of living related kidney transplantation with multiple renal arteries. Saudi J Kidney Dis Transpl 2013;24:615-9.
11. Başaran O, Moray G, Emiroğlu R, Alevli F, Haberal M. Graft and patient outcomes among recipients of renal grafts with multiple renal arteries. Transplant Proc 2004;36:102-4.
12. Chedid MF, Muthu C, Nyberg SL, Lesnick TG, Kremers WK, Prieto M, et al. Living donor kidney transplantation using laparoscopically procured multiple renal artery kidneys and right kidneys. J Am Coll Surg 2013;217:144-52.
13. Hsu TH, Su Li, Ratner LE, Trock BJ, Kavoussi LR. Impact of renal artery multiplicity on outcomes of renal donors and recipients in laparoscopic donor nephrectomy. Urology 2003;61:323-7.
14. Dunn DL, Park SC, Chou BS, Kim JY, Yang CW, et al. The long-term outcomes of transplantation of kidneys with multiple renal arteries. Transplant Proc 2010;42:4053-7.
15. Lim YM, Han X, Raman L, Ng TK, Goh TH, Vathsala A, et al. Outcome of living donor transplant kidneys with multiple arteries. Transplant Proc 2016;48:848-51.
16. Paragi PR, Klaassen Z, Fletcher HS, Tichauer M, Chamberlain RS, Wellen JR, et al. Vascular constraints in laparoscopic renal allograft: Comparative analysis of multiple and single renal arteries in 976 laparoscopic donor nephrectomies. World J Surg 2011;35:2159-66.
17. Saidi R, Kawai T, Kennealey P, Tsoufas G, Elias N, Herli M, et al. Living donor kidney transplantation with multiple arteries: Recent increase in modern era of laparoscopic donor nephrectomy. Arch Surg 2009;144:472-5.
18. Sezer TO, Solak I, Toz H, Kardaslar B, Er A, Hoscoskun C.
Long-term outcomes of kidney transplants with multiple renal arteries: A retrospective study. Transplant Proc 2012;44:1697-9.

20. Troppmann C, Wiesmann K, McVicar JP, Wolfe BM, Perez RV. Increased transplantation of kidneys with multiple renal arteries in the laparoscopic live donor nephrectomy era: Surgical technique and surgical and nonsurgical donor and recipient outcomes. Arch Surg 2001;136:897-907.

21. Tyson MD, Castle EP, Ko EY, Andrews PE, Heilman RL, Mekeel KL, et al. Living donor kidney transplantation with multiple renal arteries in the laparoscopic era. Urology 2011;77:1116-21.

22. Vaccarisi S, Bonaiuto E, Spadafora N, Garrini A, Crocco V, Cannistrà M, et al. Complications and graft survival in kidney transplants with vascular variants: Our experience and literature review. Transplant Proc 2013;45:2663-5.

23. Zorgdrager M, Krikke C, Hofker SH, Leuvenink HG, Pol RA. Multiple renal arteries in kidney transplantation: A systematic review and meta-analysis. Ann Transplant 2016;21:469-78.

24. Khamanarong K, Prachaney P, Utraravicahi A, Tong-Un T, Sripaoraya K. Anatomy of renal arterial supply. Clin Anat 2004;17:334-6.

25. Kay MD, Brook N, Kaushik M, Harper SJ, Bagul A, Nicholson ML. Comparison of right and left laparoscopic live donor nephrectomy. BJU Int 2006;98:843-4.

26. Hsu JW, Reese PP, Naji A, Levine MH, Abt PL. Increased early graft failure in right-sided living donor nephrectomy. Transplantation 2011;91:108-14.

27. Song G, Jeong IG, Kim YH, Han DJ, Kim CS, Ahn H, et al. Kidney laterality and the safety of hand-assisted live donor nephrectomy: Review of 1000 consecutive cases at a single center. Urology 2015;85:1360-6.

28. Bandín Musa AR, Montes de Oca J. Hand-assisted laparoscopic nephrectomy in living-donor kidneys with multiple arteries: Experience of a transplant center. Exp Clin Transplant 2016;14:153-6.

29. Meyer F, Nichele SA, Adamy A, Santos IS, Machado C. Early outcomes of laparoscopic donor nephrectomy with multiple renal arteries. Int Braz J Urol 2012;38:496-503.