Original Article

Management of donor kidneys with double renal arteries with significant luminal discrepancy: A retrospective cohort study

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ABSTRACT

Introduction: Side-to-side pantaloon anastomosis for renal grafts with double renal arteries (RA) with significant luminal discrepancy between graft arteries has not been reported. We hypothesized that the pantaloon technique is feasible and safe in these cases.

Materials and Methods: A retrospective review of all consecutive, open, live-related renal transplants with double RA with significant luminal discrepancy performed at our center from January 2014 to September 2018 was undertaken. Significant luminal discrepancy was defined as smaller RA constituting 30% ± 5% of total RA diameter on preoperative computed tomography angiogram. Three groups were defined: Group A - pantaloon anastomosis, Group B - end-to-side anastomosis of smaller to main RA, and Group C - separate implantation of each artery. The primary objective was to study feasibility and safety of pantaloon anastomosis measured by recipient serum creatinine levels, Doppler ultrasound, and vascular complications (vascular thrombosis and anastomotic bleed). Secondary objectives included measurement of cold ischemia time, warm ischemia time in recipient (WIR), and nonvascular recipient complications.

Results: Fifty-eight recipients had donors with double RA with significant luminal discrepancy. Group A - included 40, Group B – 5, and Group C - 13 patients. Recipient creatinine at day-7, -30, and -90 were similar among the groups. The 30-day perioperative complication rate was also similar. Group A and B had significantly lower WIR and higher cold ischemia time compared to Group C.

Conclusion: Pantaloon anastomosis is feasible in renal grafts with double RA with significant luminal discrepancy and offers advantage of lower WIR compared to separate implantation technique.

INTRODUCTION

Live-related renal transplantation in the presence of multiple donor renal arteries (RA) is technically challenging and use of vascular reconstruction techniques may be required in these cases.[1] Double RA are the most common anatomical variation in number.[2] There are two available options for cases with double RA with almost equal caliber: side-to-side anastomosis of both RA to make a pantaloon anastomosis and separate implantation of each artery. If technically feasible, pantaloon anastomosis is the preferred reconstructive strategy as it enables performance of single implantation and lowering of warm ischemia time in recipient (WIR) as compared to separate implantation.[3] However, various authors have used more different reconstructive options in cases with significant luminal discrepancy between the two RA, including end to side anastomosis of the smaller artery to the main renal artery, separate implantation of each artery to either inferior epigastric artery or to the external/internal

Access this article online	
Quick Response Code:	Website: www.indianjurol.com
	DOI: 10.4103/iju.IJU_196_20

Received: 19.04.2020, **Revised:** 04.06.2020,

Accepted: 11.06.2020, **Published:** 01.07.2020

Financial support and sponsorship: Nil.

Conflicts of interest: There are no conflicts of interest.

iliac artery and sacrificing the smaller upper pole artery (in cases where smaller renal artery supplies <5% of the total renal parenchyma).[4] End to side anastomosis of smaller renal artery to main renal artery is a technically challenging option whereas separate implantation of each artery to iliac arteries causes prolonged WIR which can theoretically affect graft outcome due to increased risk of acute tubular necrosis.[3,5] The inferior epigastric artery may not always be available for anastomosis.[5] The best reconstructive option for this group is still debatable. Compared to end to side anastomosis of smaller RA to main RA, the pantaloon technique is technically less demanding and theoretically leads to formation of a wider channel for blood flow to the graft. However, pantaloon anastomosis has not yet been described in cases with significant luminal discrepancy. We hypothesized that pantaloon technique is feasible and safe in cases with significant luminal discrepancy between two graft RAs.

MATERIALS AND METHODS

We performed a retrospective review of our prospectively maintained renal transplant database. All consecutive open renal transplants performed between January 2014 and September 2018 were included in the study. All transplants were conducted by a single-experienced renal transplant surgeon at a single tertiary care institution. Inclusion criteria included all live-related open renal recipients with double RAs with significant luminal discrepancy. Significant luminal discrepancy was defined when the smaller renal artery diameter was 30% ± 5% of the total renal arterial diameter at origin (as measured on the preoperative computed tomography [CT] scan). Patients with incomplete medical records or missing data, smaller renal artery diameter <25% of the total arterial diameter and patients in which the smaller upper polar renal artery was sacrificed were excluded from the study. Based on the type of vascular reconstruction/implantation, the recipients were divided into three groups: Group A had side-to-side pantaloon anastomosis, Group B had end to side anastomosis of smaller RA to main RA, and Group C had separate implantation of each artery. The primary objective of the study was to assess the feasibility and safety of pantaloon anastomosis, measured by recipient serum creatinine levels, Doppler ultrasound on postoperative day one to see perfusion of transplant kidney and recipient vascular complication rate (vascular thrombosis and anastomotic bleed). Secondary objectives included measurement of cold ischemia time, WIR, and nonvascular recipient complication rate. Data collection included demographic details of recipients, preoperative CT angiography findings of the donors; intraoperative details of recipient surgery including type of renal artery reconstruction/implantation, cold ischemia time, WIR, and intraoperative complications; postoperative recipient creatinine at day-7, -30 and -90, and 30-day postoperative complications. Postoperative complications were graded according to the Clavien–Dindo classification system.

All donors underwent laparoscopic donor nephrectomy. Once the kidney was retrieved, each artery was identified, cannulated, and cold Histidine-Tryptophan-Ketoglutarate (Custodiol® HTK) solution was infused till clear effluent was seen from the vein. Bench preparation was done at the recipient bed side and each artery length and luminal diameter reassessed for possible single lumen anastomosis. Each artery was dilated with vascular dilators before reconstruction or implantation. The decision for type of vascular reconstruction was based on operating surgeon's discretion. Proline 7-0 suture was used for fashioning the pantaloon anastomosis and for end to side reconstruction of smaller RA to main RA. All end to side reconstructions were done with interrupted suturing whereas continuous suturing was used for the pantaloon anastomosis after adequate spatulation of each artery [Figure 1]. In case the arteries could not be brought together without tension at bench reconstruction, direct implantation was done (most commonly in external iliac vessel followed by internal iliac vessel or inferior epigastric artery). In cases where anastomosis was done to iliac arteries, clamps were released after completion of both anastomosis. In case inferior epigastric artery was used, vascular clamps of main renal artery anastomosis were released before anastomosis of smaller artery to inferior epigastric artery was performed.

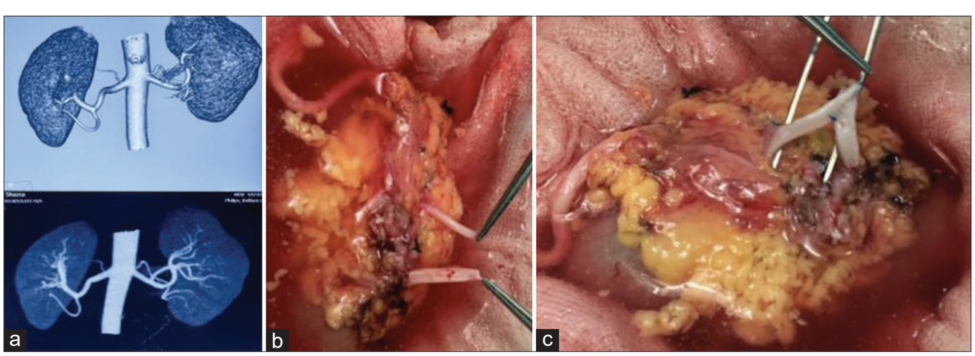

Figure 1: (a) Preoperative computed tomography angiogram and (b and c) operative photograph showing Pantaloon anastomosis in a patient with two renal arteries with luminal discrepancy

Postoperatively, all recipients were kept in surgical intensive care unit for 1–2 days and then shifted to ward. Urethral catheter was removed on day 5 and drain was removed when drainage was minimal. Most patients were discharged by day 7. Analgesia was given using intravenous paracetamol and tramadol. All patients received thromboprophylaxis with calf pump and low molecular weight heparin in perioperative period. Antibiotics were given as per the hospital protocol. All recipients were monitored daily for renal function, blood counts, and urine output. Doppler ultrasound was done on postoperative day one to see perfusion of transplant kidney. Tacrolimus levels were monitored on Day 2, 5, and 7 before discharge. Cases where renal function failed to improve or deteriorated were further evaluated as needed.

Statistical analysis

Continuous variables were summarized as mean and standard deviation and analyzed using one-way ANOVA test. Categorical variables were recorded as count with percentage and analyzed using Chi-square or Fischer's exact tests as appropriate. $P < 0.05$ was considered statistically significant. All calculations were performed with MedCalc version 19.1.1 (MedCalc for Windows, version 19.1.1 (MedCalc Software, Ostend, Belgium).

RESULTS

A total of 718 patients underwent live-related open renal transplant during the study. Five hundred and eighty patients had single renal artery and were excluded. One hundred and thirty-eight patients had multiple renal vessels, out of which 120 patients had double RA. Out of these, 58 patients were found to have significant luminal discrepancy as defined above and were included in the final analysis. Group A included 40 patients, group B 5 patients, and group C included 13 patients [Table 1]. Demographic parameters of all three groups were similar [Table 2]. There was no significant difference in the serum creatinine levels at day-7, -30, and -90 among the three groups. The postoperative complication rate (both vascular and nonvascular) among the three groups was similar [Table 3]. One patient in each group developed slow graft function (defined as failure to normalize serum creatinine within 72 h of transplant but not requiring hemodialysis[1]) and were managed conservatively. Doppler ultrasound showed slightly raised resistive index in the graft arteries in each group. Doppler ultrasound of remaining recipients showed uniform perfusion of transplant kidney. All patients were managed conservatively and gradually improved. No patient developed vascular thrombosis. One patient in group B required re-exploration immediately after closure, while on table, due to bleeding from the anastomosis which was controlled with additional sutures. One patient in group C required re-exploration in the immediate postoperative period due to bleeding from inferior epigastric artery anastomosis. There were no re-explorations in group A. Patients in group A and B had significantly lower WIR as compared to group C (45.26 ± 12.6 and 46.78 ± 10.65 vs. 56.38 ± 10.12 min, $P < 0.001$). Cold ischemia time in group A and B were higher than group C (52.67 ± 12.32 and 56.54 ± 16.43 vs. 43.24 ± 11.24 min, $P < 0.001$).

DISCUSSION

Renal transplantation is the best option for patients suffering from end-stage renal disease (ESRD).[6] Conventionally, given a choice, the side with single renal artery and vein are chosen for donation due to its technical simplicity and good recipient outcomes.[7] However, due to high number of patients suffering from ESRD and the relative shortage of donor organs, as well as with refinement in vascular reconstruction techniques, kidneys with multiple RA are now considered acceptable for transplant.[8]

Table 1: Type of reconstruction and implantation technique in recipient

Type of reconstruction	Anastomosis to EIA (end to side)	Anastomosis to IIA and/or its branches (end to end)	Anastomosis to both EIA (end to side) and IIA (end to end)	Anastomosis to inferior epigastric vessels
Group A (Pantaloon, *n*=40)	27	13	N/A	N/A
Group B (end to side of smaller artery to main renal artery, *n*=5)	4	1	N/A	N/A
Group C (separate implantation, *n*=13)	3 (both in EIA)	3 (both in IIA)	4 (one in EIA and one in IIA)	3 (smaller branch)

EIA=External Iliac artery, IIA=Internal iliac artery, N/A=Not available

Table 2: Demographic and preoperative details

Parameter	Group A (*n*=40)	Group B (*n*=5)	Group C (*n*=13)	*P*
Age (years), mean±SD	38.9±15.4	43.5±10.7	40.28±20.16	0.745
Males/females	30/10	4/1	8/5	0.235
Body mass index (kg/m^2), mean±SD	22.8±4.2	24.2±3.8	21.5±4.6	0.843
Previous abdominal surgery, *n* (%)	4 (10)	1 (20)	2 (15)	0.654
Accessory/complex venous anatomy, *n* (%)	2 (5)	0	0	0.214
Mean diameter (smaller artery, millimeters), mean±SD	2.8±0.4	2.5±0.3	2.9±0.3	0.198
Mean diameter (larger artery, millimeters), mean±SD	6.7±0.5	7.1±0.4	6.7±0.6	0.262

SD=Standard deviation

Table 3: Operative and postoperative parameters

Parameter	Group A (*n*=40)	Group B (*n*=5)	Group C (*n*=13)	*P*
Recipient serum creatinine at day 7 (mg/dl), mean±SD	1.23±0.76	1.42±0.78	1.34±0.65	0.687
Recipient serum creatinine at day 30 (mg/dl), mean±SD	1.19±0.62	1.19±0.70	1.18±0.92	0.771
Recipient serum creatinine at day 90 (mg/dl), mean±SD	1.18±0.52	1.18±0.70	1.18±0.86	0.986
Postoperative complications (Clavien-Dindo Grade), *n* (%)				
I	2 (5)	1 (20)	1 (7.6)	0.879
II	3 (7.5)	1 (20)	1 (7.6)	0.780
III	0	1 (20)*	1 (7.6)*	0.564
IV	0	0	0	NA
V	0	0	0	NA
Warm ischemia time in donor (min), mean±SD	5.25±1.3	5.36±2.47	5.39±1.65	0.953
Warm ischemia time in recipient (min), mean±SD	45.26±12.6	46.78±10.65	56.38±10.12	<0.001
Cold ischemia time (min), mean±SD	52.67±12.32	56.54±16.43	43.24±11.24	<0.001

*Vascular complications - anastomotic bleed requiring re-exploration. SD=Standard deviation

Multiple RA are the most common anatomical variant seen in donor kidneys and are found in 18%–30% of all potential kidney donors.[9] Several reports have reinforced the safety and acceptable outcomes of engraftment of kidneys with multiple arteries.[1,9] However, the procedure is technically challenging and several options for *ex vivo* arterial reconstruction or intracorporeal implantation are available in these cases.[9] For grafts with equally sized RA, fashioning of a side-to-side pantaloon anastomosis of both RA to make a single lumen for implantation remains the preferred surgical technique.[4] If technically feasible and performed without tension, this anastomosis offers the benefit of performing the procedure on bench and also has lower WIR as compared to separate implantation.[4]

However, the optimum modality for surgical reconstruction/implantation is less clearly defined in cases with significant discrepancy between the two RA. Small upper polar RA, supplying <5% of the renal parenchyma can usually be safely ligated without any significant loss of renal function.[1] However, as all RA are end arteries,[10] in all other scenarios (including a small lower polar artery, which usually supplies the donor ureter), arterial reconstruction or implantation of the smaller renal artery is required.[1] Possible management methods for these cases include a pantaloon anastomosis, end to side anastomosis of smaller artery into main renal artery and separate implantation into either iliac vessels or inferior epigastric artery.

What constitutes significant luminal discrepancy has not been previously specified in the literature. We believe that a 30/70 cut off for the ratio of diameter of smaller to larger artery represents an acceptable trade off. Therefore, we have chosen this ratio to define "significant luminal discrepancy" between the RA. We have shown in our study, that pantaloon anastomosis is feasible in these cases and provides acceptable graft outcomes. Pantaloon anastomosis provides advantages over the other methods. End to side anastomosis of smaller artery to main RA is a technically challenging reconstruction.[5] While most of the studies in literature have not found any difference in graft outcomes among the various reconstructive/implantation techniques,[11] a study by Yamanaga *et al*.[5] found that 10-year overall survival and death-censored graft survival rates were significantly worse for end to side arterial anastomosis than separate implantation. The authors did not perform pantaloon anastomosis in any case. Among the three techniques, the end to side technique theoretically leads to the smallest combined diameter of the final arterial channel and therefore is the most vulnerable to stenosis. Furthermore, according to the authors, thrombus, or hyperplasia of the smaller artery in this case could potentially spread to the main artery, leading to chronic ischemia of the entire kidney.

Another study by Paramesh *et al*.[12] similarly showed that the 5-year graft survival for end to side anastomosis was markedly lower at 40% compared to 70% for side-to-side group and 90% for direct anastomosis group. Separate implantation of smaller artery in external or internal iliac artery runs the risk of prolonging the WIR potentially leading to worse graft outcomes.[13] Although sequential anastomosis of the smaller artery with the inferior epigastric artery is another good option described earlier by the senior author,[4] the inferior epigastric artery may not always be available due to atherosclerosis or insufficient diameter relative to the accessory renal artery.[5] The smaller renal artery may also be prone to thrombosis or stenosis. Therefore, we believe that pantaloon anastomosis overcomes the above complications of its alternative options while providing a larger diameter channel thus reducing the risk of stenosis.

We could successfully achieve a pantaloon anastomosis in 40 out of 58 cases with significant arterial discrepancy. It is important to note that the 30/70 ratio is based on the preoperative CT assessment. We routinely dilate both arteries using vascular dilators during bench dissection. This widens the smaller artery and may have helped in performing the side-to-side anastomosis. Although our follow-up is short, none of the patients in the Pantaloon group developed arterial thrombosis or graft loss and there were no re-explorations in the group.

There are a few limitations of our study. It is a retrospective study and carries its attendant bias. The overall numbers in end to side and separate implantation groups are low and the decision to perform any particular reconstructive technique was based on the surgeon's discretion. We primarily relied on clinical parameters to see graft outcomes. The precise evaluation of impact of any vascular reconstruction is best assessed by postoperative CT angiogram, which was not done in our cases in view of increased cost to the patient and risk of contrast-induced graft dysfunction. However, all procedures in our study were performed by a single surgeon and at single center, which increases the reliability of results. In addition, we used standardized technique of vascular anastomosis in all cases.

To the best of our knowledge, ours is the first study demonstrating feasibility and safety of side-to-side pantaloon anastomosis in cases of double RA with significant luminal discrepancy and we strongly feel that if performed with expertise, this technique provides distinct advantages over its alternatives.

CONCLUSION

Double donor RA is preferably reconstructed on bench to minimize prolonged WIR. Pantaloon reconstruction is feasible and safe in renal grafts with double RA with significant luminal discrepancy with acceptable short-term graft function and complications.

REFERENCES

1. Wijayaratne DR, Sudusinghe DH, Gunawansa N. Multiple renal arteries in live donor renal transplantation; impact on graft function and outcome: A prospective cohort study. Open J Organ Transpl Surg 2018;8:1-11.
2. Hernández-Rivera JCH, Espinoza-Pérez R, Cancino-López JD, Silva-Rueda RI, Salazar-Mendoza M, Paniagua-Sierra R. Anatomical variants in renal transplantation, surgical management, and impact on graft functionality. Transplant Proc 2018;50:3216-21.
3. Kumar A, Gupta RS, Srivastava A, Bansal P. Sequential anastomosis of accessory renal artery to inferior epigastric artery in the management of multiple arteries in live related renal transplantation: A critical appraisal. Clin Transplant 2001;15:131-5.
4. Makiyama K, Tanabe K, Ishida H, Tokumoto T, Shimmura H, Omoto K, *et al*. Successful renovascular reconstruction for renal allografts with multiple renal arteries. Transplantation 2003;75:828-32.
5. Yamanaga S, Rosario A, Fernandez D, Kobayashi T, Tavakol M, Stock PG, *et al*. Inferior long-term graft survival after end-to-side reconstruction for two renal arteries in living donor renal transplantation. PLoS One 2018;13:e0199629.
6. Soliman SA, Shokeir AA, Kamal AI, El-Hefnawy AS, Harraz AM, Kamal MM, *et al*. Long-term outcome of grafts with multiple arteries in live-donor renal allotransplantation: Analysis of 2100 consecutive patients. Arab J Urol 2011;9:171-7.
7. Mazzucchi E, Souza AA, Nahas WC, Antonopoulos IM, Piovesan AC, Arap S. Surgical complications after renal transplantation in grafts with multiple arteries. Int Braz J Urol 2005;31:125-30.
8. Ali-El-Dein B, Osman Y, Shokeir AA, Shehab El-Dein AB, Sheashaa H, Ghoneim MA. Multiple arteries in live donor renal transplantation: Surgical aspects and outcomes. J Urol 2003;169:2013-7.
9. Benedetti E, Troppmann C, Gillingham K, Sutherland DER, Payne WD, Dunn DL, *et al*. Short- and long-term outcomes of kidney transplants with multiple renal arteries. Ann Surg 1995;221:406-14.
10. Mir NS, Ul Hassan A, Rangrez R, Hamid S, Sabia , Tabish SA, *et al*. Bilateral duplication of renal vessels: Anatomical, medical and surgical perspective. Int J Health Sci (Qassim) 2008;2:179-85.
11. McLoughlin LC, Davis NF, Dowling CM, Power RE, Mohan P, Hickey DP, *et al*. Ex vivo reconstruction of the donor renal artery in renal transplantation: A case-control study. Transpl Int 2014;27:458-66.
12. Paramesh A, Zhang R, Florman S, Yau CL, McGee J, Al-Abbas H, *et al*. Laparoscopic procurement of single versus multiple artery kidney allografts: Is long-term graft survival affected? Transplantation 2009;88:1203-7.
13. Antonopoulos IM, Yamaçake KG, Oliveira LM, Piovesan AC, Kanashiro H, Nahas WC. Revascularization of living-donor kidney transplant with multiple arteries: Long-term outcomes using the inferior epigastric artery. Urology 2014;84:955-9.

How to cite this article: Panwar P, Bansal D, Maheshwari R, Chaturvedi S, Desai P, Kumar A. Management of donor kidneys with double renal arteries with significant luminal discrepancy: A retrospective cohort study. Indian J Urol 2020;36:200-4.