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Results of anastomosis of accessory lower polar graft artery to internal iliac artery in renal transplantation

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***Abstract*---**Background: Our objective is to perform a renal graft transplant using multiple arteries where the lower polar artery will indeed be anastomosed to the internal iliac artery end to side following declamping the main arterial supply in terms of ischemia time, diuresis, graft perfusion, and postoperative clinical parameters and investigations. Methods: Fifty live donors underwent vascular anastomosis of the graft auxiliary lower polar artery to recipient internal iliac artery end to side anastomosis with various renal arteries bilaterally, including lower polar artery in chosen kidney. The recipients' intraoperative warm and total ischemia periods, as well as their postoperative incidence of acute tubular necrosis, were assessed (ATN). Diuresis, urinary output, and creatinine levels at 1, 3, and 5 days after surgery, as well as at 2 months afterwards. MRI and

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Doppler ultrasonography, if necessary. Results: In contrast to warm, the mean total ischemia time was 20.86 minutes. Low incidence of ATN (8%) was controlled and postoperative recovery went without a hitch. Regarding postoperative urine output and serum creatinine level monitoring, clinical and laboratory indicators were satisfactory. Depending on the assessment method, colour Doppler ultrasonography reveals well perfused transplanted grafts with a satisfactory peak systolic velocity ratio in the auxiliary graft artery. Conclusions: The warm and total ischemia times are decreased by auxiliary graft artery sequential anastomosis. Lower polar artery end-to-side anastomosis approach lowers the danger of kinking and flow turbulence in lower polar artery, making internal iliac artery a favourable option as the implant location. In addition to being affordable, colour doppler ultrasonography provides a reliable way to assess the anastomosed graft vasculature.

***Keywords*---**Anastomosis, Lower polar graft artery, Iliac artery, Renal transplantation.

Introduction

When a patient has end-stage renal illness, kidney transplantation is still the preferred course of therapy since it increases survival and quality of life (1). Finding appropriate organ donors is becoming more difficult due to the ongoing donor scarcity. In order to address the problem of a donor scarcity, many solutions have been implemented, including broadening donor criteria and creating live donor programs(2) (3). However, before extending donor criteria, the most crucial problem is donor safety for live donors (4).

Organs with multiple arteries have been included in several studies of living-related renal transplantation procedures with the expectation of similar graft outcomes compared to organs bearing single arteries. This is done to broaden the inclusion criteria for renal transplant programmes and to increase the donor pool (5).

Six studies did not properly identify the kind of artery reconstruction (6-11). Multiple renal arteries (MRAs) were formerly thought to be a relative contraindication due to the higher risk of vascular and urologic problems, but MRAs are now essential and have been made achievable by better procedures (12,13). Sequential anastomosis was advised by vascular reconstruction procedures to decrease the frequency of acute tubular necrosis and ischemia time (14).

After declamping the main arterial supply, we will assess the results of the reconstruction technique of the accessory lower polar graft artery to internal iliac artery end to side anastomosis with regard to the duration of ischemia, the perfusion of the graft, diuresis, and postoperative clinical parameters and investigations.

Patients and Methods

Between July 2016 and March 2020, this research was conducted on fifty live donors who had bilateral multiple renal arteries, including the lower polar artery in a chosen kidney. The Ethics Committee of the Bani Suef University Faculty of Medicine gave its approval to the project. All participants in this study provided their informed consent.

Our study included donors who met the requirements of the 2014 EAU Guidelines on Renal Transplantation, such as donors with multiple bilateral renal arteries with the lower polar artery, multiple unilateral renal arteries with split function less than 5 ml/min in the multiple supplied kidneys, multiple unilateral renal arteries with abnormalities like backpressure, aberrant vessels, or malpositioned kidneys, and multiple unilateral right renal arteries in females in the childbearing period. Our investigation eliminated donors from renal transplant patients who had severe iliac artery calcification and arteriosclerosis.

All patients were submitted to
Detailed social history, physical examination, medical psychological assessment, and evaluation.

Laboratory investigations
Pursuant to EAU Guidelines on Renal Transplantation, regular laboratory testing and serological assessment for herpes virus, HIV-1 and HIV-2, hepatitis B surface antigen (HBs Ag), and hepatitis C (HCV) (2014).

Radiological examination
Included a CT angiography (renal arteriography) with an excretion phase to see the collecting system and a renal isotope scan. Duplex CT angiography for the recipient of a suspected vascular lesion. Two adjacent operating rooms (ORs) are used for the simultaneous commencement of the surgeries; one team does the nephrectomy while the other gets the patient ready.

Donor operation
All donors underwent open live donor nephrectomy by a supracostal incision on the 11th rib in the flexed lateral decubitus posture. The retroperitoneal route was used, and the auxiliary lower polar artery was carefully dissected after dissection over the renal arteries. The veins split as they reached the kidney's maximal length. After careful dissection to protect its blood supply and the surrounding fasciae, the ureter is also separated distally. To preserve the kidney and reduce ischemia reperfusion damage, mannitol and diuretics were infused into the donor during extraction as well as significant amounts of crystalloids (3.5–4 litres) throughout the intervention.

Bench perfusion
Following removal, the kidney was perfused on the back table with 500 ml of verapamil-infused, cooled normal saline solution at 4 C and 100 cmH2O of infusion pressure. During the infusion technique, donor kidneys were kept in an ice-filled normal saline solution.

Recipient operation

Operative bed preparation
The procedures for harvesting and transplanting were carried out using the standard methods: through a Gipson incision in the iliac fossa, an extraperitoneal approach, careful dissection over the recipient iliac vessels, special attention to the lymphatic system to prevent postoperative lymphoceles, division and ligation to all tributaries of the common and external iliac vein so that they become freely mobile and accessible, and placement of a vascular clamp to be prepared for anasto A coronary bulldog clamp is placed at its proximal end after the internal iliac artery is divided and ligated down to its distal end to provide a complete length for anastomosis.

Vascular anastomosis
Using contionus 5/0 or 6/0 contionus polyprolene impermeable sutures, the graft vein was anastomosed to either the external or common iliac vein on the side. A substantial vascular statinisky clamp is applied to the iliac vein at the site of the anastomosis, a venotomy is created, one angle of the venotomy is sutured to the graft vein, and the other serves as a stay. Running sutures are then started by the posterior limb until they reach the stay, at which point they are removed, and continue to be finished by the anterior limb where they are tied to the started angle.

After removing the venous clamp at the conclusion of the venous anastomosis, a bulldog clamp is positioned at the hilar end of the graft vein to stop retrograde blood flow. After a punsh arteriotomy is performed to the iliac artery at the designated location for the anastomosis, the primary graft artery is anastomosed to either the common or external iliac artery end to side. The major graft artery does not ever need to be spatulated prior to anastomosis.

Declamping the iliac artery allows the graft to be perfused. After the graft's venous catheter is removed, it is discovered that the graft is totally perfused with the exception of a little lower polar section fed by an auxiliary lower polar arterial. The auxiliary lower polar graft artery was then subjected to the required spatulation using Pott's scissor, followed by an end-to-side anastomosis with the internal iliac artery using polyproline 0/7 in a running continuous fashion. The lower pole of the graft is subsequently given oxygen by the removal of the internal iliac artery bulldog. All patients get low molecular weight heparin intraoperatively in a prophylactic dosage, and this treatment lasts for 5 days after surgery.

Ureterovesical anastomosis
All recipients underwent ureterovesical anastomosis using the modified extravesical ureteral reimplantation technique described by Abo-Elela A et al. in 2007 through an extravesical anastomosis with the distal end of the stent tied to the urethral catheter that was to be removed with it without needing to undergo additional endoscopic intervention postoperatively.

Immunosuppression protocols
All recipients of organ transplants had immunosuppression with a combination of Tacrolimus, prednisone, and mycophenolate mofetil.

All recipients were evaluated regarding:

- Warm-up and total ischemia times during surgery.
- The prevalence of acute tubular necrosis after surgery (ATN).
- Post operative urine output and diuresis.
- Post operative creatinine levels at 1, 3, 5 days postoperative and 2 months later.
- Doppler ultrasound for all patients were done within one week post operative.
- MRI angiography was performed to some patients.

Statistical analysis

Using SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA), all data were gathered, tabulated, and statistically analysed. Qualitative data were shown as frequencies and relative percentages. Quantitative information was presented as mean ± SD (Standard deviation). Every statistical comparison used a two-tailed significance test. A P-value of 0.05 or below denotes significance.

Results

Patients' characteristics, ischemia time, urine output, serum creatinine and color Doppler peak systolic velocity (PSV) are shown in table 1.

Table 1: Patients' characteristics, ischemia time, urine output, serum creatinine and color Doppler peak systolic velocity (PSV)

	N	Minimum	Maximum	Mean	S. D
BMI	50	19	29	24.70	3.03
Recipient age	50	38	61	49.62	6.40
Total ischemia time	50	17	29	20.86	2.27
Warm ischemia	50	9	13	9.96	1.18
Output 1	50	300	19900	14774.00	4540.02
Output 3	50	1100	17100	11136.00	3694.49
Output 5	50	3000	12900	7872.00	2219.95
S. CR D – 1	50	4.9	7.1	5.97	0.62
S.CR D1	50	2.9	5.6	3.78	0.49
S.CR D3	50	1.6	5	2.63	0.72
S.CR D5	50	0.9	4.1	1.77	0.66
S.CR D 2months	50	0.8	4.7	1.36	0.56
External PSV	50	134	156	146.20	6.31
PSV1	50	82	270	149.02	20.74
Ratio 1	50	0.59	1.8	1.02	0.13
PSV 2	50	135	160	148.88	6.98
Ratio2	50	0.91	1.08	1.02	0.03

BMI: body mass index, PSV: Peak systolic velocity, S. CR: serum creatinine

Regarding donors' gender characteristics, there were 45 (90%) males and 5(10%) females. Regarding recipients' gender characteristics, there were 42 (84%) males and 8 (16%) females. (Table 2)

Table 2: Donor and recipients gender characteristics of the studied patients

Donor sex	N	%
Male	45	90
Female	5	10
Total	50	100
Recipient sex		
Male	42	84
Female	8	16
Total	50	100

Incidence of acute tubular necrosis was 8% of all cases (only 4 cases) all of them managed medically and passed smooth post operative course after that. (Table 3)

Table 3: Incidence of acute tubular necrosis of the studied patients

ATN	N	%
Yes	4	8
No	46	92
Total	50	100

Urine output measured in cubic centimeter and monitored daily and recorded in this study in day 1, 3 and 5 as initial follow up measure for graft function. (Table 4)

Table 4: urine output studied patients on day 1,3 and 5

Output	Day 1	Day 3	Day 5
Range	300 – 19900	1100 – 17100	3000 – 12900
Mean ± SD	14774 ± 4540.02	11136 ± 3694.49	7872 ± 2219.95
T. test	45.629		
p. value	0.001*		

*: significant as p value <0.05.

Serum creatinine milligrams (mg) per deciliter (dL) and other laboratory study was measured daily and recorded in this study in day 1,3 and 5 for close observation and correlation with general condition and urine output. (Table 5)

Table 5: Serum creatinine of the studied patients

S. CR	Day – 1	Day 1	Day 3	Day 5	2 months
Range	4.9 –7.1	2.9 –5.6	1.6 –5	0.9 –4.1	0.8 –4.7
Mean ± SD	5.97 ±0.62	3.78 ±0.49	2.63 ±0.72	1.77 ±0.66	1.36 ±0.56
T. test	449.463				
p. value	0.001*				

S. CR: Serum creatinine, *: significant as p value <0.05.

Discussion

The preferred course of therapy for ESRD patients is renal transplantation. Dialysis has a lower 5-year patient survival rate (75–87%) than transplant (94–97%). (15) The best organ source for recipients is live kidney donation, which also has the potential to favour preemptive kidney transplantation (before to commencing dialysis), which prevents difficulties from the dialysis process (16). Given that having more than one renal artery has been linked to an increased risk of vascular problems such arterial thrombosis and renal artery stenosis (18). Polar artery ligation may also result in urologic consequences including infarction and infection (19).

J.K. Hwang et al. (20) evaluated the results of kidney transplantation utilising allografts with numerous arteries and discovered that the presence of multiple renal arteries had no negative effects on allograft or patient survival when compared to the transplantation of a single renal artery. Additionally, it didn't seem that the kind of arterial anastomosis—whether the major renal artery was joined end-to-end to the internal iliac artery or end-to-side to the exterior iliac artery—affected either the survival of the graft or the propensity for vascular or urologic problems.

Small low polar renal arteries cannot be sacrificed during implantation since they may be the ureter's sole source of irrigation. The ureter will become ischemic and then necrose if this vessel thromboses (21). Although problems such stenosis and thrombosis are more prone to develop in these circumstances when MRA are present (22), patient or graft survival is unaffected (23).

Konomi was the first to mention using the inferior epigastric artery for repair (23). In 15 patients, the inferior epigastric artery was utilised for the anastomosis of many renal arteries, particularly the lower polar arteries, and assessed by A Abou-Elela et al (24) for post-transplant graft performance without an increase in the prevalence of pertinent problems. Clinical indicators, diuresis, and serum creatinine were compared to the group with a single graft artery. Additionally, the anastomosis may be carried out upon declamping without increasing the duration of ischemia.

Certain surgeons choose direct accessory artery anastomosis over sequential anastomosis to reduce ischemia duration and maximise the function of the transplanted graft, however there are some risks involved. Sometimes, there is a significant difference in size between the auxiliary graft artery and the artery utilised for anastomosis. Additionally, the orientation may interfere with the procedure, which may cause strain or kinking following surgical implantation (25).

The internal iliac artery is susceptible to kinking, which might result in vascular occlusion, and the lumen is often out of alignment, making anastomosis difficult and complicated (26). Additionally, end to end anastomosis has been observed to have a worse rate of graft survival than end to side anastomosis and a threefold increased chance of developing stenosis (27). (28). In this research, we assessed the method for sequentially joining the internal iliac artery and the auxiliary lower

polar graft artery end to side. There have been 50 renal transplant surgeries using donors who had open donor nephrectomy, where the chosen kidney had a single major arterial supply and a second lower polar artery. The recipients were assessed intraoperatively by total and warm ischemia time, and postoperatively by incidence of acute tubular necrosis, urine output, serum creatinine level, and colour Doppler ultrasound for transplanted vessels. The operations were carried out by the same surgical team and managed by the same nephrology team to standardise all circumstances.

Given that the number of graft vessels is one of the risk variables for post-transplant thromboembolic symptoms (29), (30). Therefore, heparin intraoperative prophylaxis was used to safeguard all procedures performed for this research, and it was continued until the fifth postoperative day. The bench reconstruction of MRA, which has been reported in many literatures as using the auxiliary graft artery, has been accepted as a standard procedure in major transplant facilities (31). But if the graft is appropriately perfused and chilled, this approach, which is predicted to lengthen the ischemia period, is not enough to harm it (32).

Because the internal iliac artery is "end-to-end" in construction and the kidney may be positioned in the ideal location inside the iliac bed, this anastomosis has been proven to provide a suitable position for the kidney (33). Unfortunately, the lumen is often out of alignment, which makes anastomosis challenging and complicated. Additionally, the internal iliac artery is susceptible to kinking, which may result in vascular occlusion (34). Additionally, end to end anastomosis had been observed to have a worse rate of graft survival than end to side anastomosis and to have a threefold greater chance of developing stenosis (35). (36).

Anastomosis time (WIT), also known as warm ischemia time, may be changeable and affect the success of kidney transplantation. It relies on the surgeon's technical abilities, the procedure's circumstances, the number of vessels used, the graft's anatomical irregularities, and the recipient's obesity. Extended WIT was linked to longer hospital stays after kidney transplantation (37) and worse long-term graft survival following kidney transplants using both live and dead donors (38).

According to research, WIT damages proximal tubular cells the most and may cause acute tubular necrosis (ATN), which retards transplant function (39). Thus, successive anastomosis aims to decrease the frequency of ATN and the ischemia time.

Warm ischemia lasted between 9 to 13 minutes in our research, with a mean of 9.9 minutes. It is determined from the beginning of the anastomosis till the major graft artery is declamped. It took 6 to 12 minutes in Amirzargar M'set al's (40) study to reconstruct the accessory artery to the external and internal iliac arteries in 2 cases, or from end to side to the main graft artery in 2 cases, but as they noted, it took much less time to perform inferior epigastric anastomosis in 2 cases.

Total (rewarm) ischemic time (TIT), according to Kadotani Y. et al (41) is referred to as the main artery's ischemic time. The inferior epigastric artery or the

common iliac artery used in conjunction with successive revascularization did not result in a greater TIT than when a single anastomosis was performed using a single artery. It was 40.0 minutes in Group D. On the other hand, when numerous anastomosis were performed in situ, the TIT was greater.

Shorter WIT has been linked to a lower frequency of acute tubular necrosis after renal transplantation, according to some researchers (42), whereas others found no significant difference between first and second WIT in terms of the risk of renal graft failure (43, 44). (45). The various results may be explained by measuring the kidney core temperature (46) (47). Data suggested that WIT with a duration of less than 30 minutes had a little therapeutic impact (48).

Tennankore K et al. just released two significant studies assessing the significance of warm ischemia in kidney transplantation (49). WIT lasting more than 30 minutes was linked to a significantly greater adjusted relative risk for the composite event of mortality or graft failure, according to a research on 131,677 kidney transplant patients. The adjusted relative hazard for mortality or graft failure increased by 23% in the event of WIT >60 min. Similar findings were made by Heylen et al. (50), who examined the impact of anastomosis time on the results of 669 first single kidney transplantations. They discovered that WIT independently increased the risk of delayed graft function and independently decreased allograft function after transplantation. Prolonged WIT was linked to a higher incidence of tubular atrophy and interstitial fibrosis in the following protocol biopsies.

In a research on 1245 consecutive dead donor kidney transplantations in Europe, Weissenbacher A et al (51) discovered that anastomosis time was a major independent determinant not only for the graft but also for patient survival. Longer hospital stays after kidney transplantation were similarly associated with prolonged WIT. Due to delayed graft function, every five minutes of prolonged anastomosis time was linked to an additional day in the hospital (52). In this research, 8% of patients (four instances) with ATN diagnosis by clinical course and regular labs had incidence suspected in the first and second post-operative days. Up to recovery in all instances and adequate urine output, careful observation, continuous monitoring, and fluid replenishment with medical treatment were sufficient. It wasn't in the research by Amirzargar M'set al. (53). None of the Group D patients in the study by Y. Kadotani et al. developed acute tubular necrosis, but it was 4.1 in the group that anastomosed the single main graft artery end-to-end to the internal iliac artery or end-to-side to the external iliac, common iliac artery, or aorta with a single anastomosis (control group).

Early post-transplantation dieresis is a good indicator of how well an allograft would do (54). The probability of hyper acute rejection, kinking of the renal artery, vascular thrombosis, urine leak, or ureteric obstruction increases when there is sudden anuria in the first few hours after surgery, particularly when there has been previous immediate graft function. A good measure for predicting graft outcome is a high urine volume during the first post-transplant days (55).

All of the participants in our research had satisfactory urine production during the whole investigation. It is noted every day and reported in our research on days

1, 3, and 5 after surgery. In D1, 5500 in D3, and 5100 in D5, the average was 5200 cc. The Jaffé technique is a simple way to detect serum creatinine, which is a cheap way to assess renal failure (56). Serial plasma creatinine levels are a reliable way to determine transplant function (57).

All patients in our research had daily serum creatinine samples taken. recorded on days 1, 3, and 5 after surgery. Average blood sugar levels were 3.7 mg/dl on the first post-op day, 2.07 mg/dl on the third, and 1.92 mg/dl on the fifth post-op day. With the exception of 3 instances (6%) that had increased blood creatinine levels and were resubmitted to dialysis because to acute cellular rejection of autoimmunity, the graft continued to function well at the two-month checkup. In the 2008 research by A Abou-Elela et al., it was 1.4. According to a 2013 research by Amirzargar M'set al., it was 1.79 ± 0.72. In the Kadotani Y et al., 2005 research, it was also varying between 1.4 and 1.49 mg/dl in various groups with no statistically significant difference across study groups, however it was 1.9 in group D.

Of all surgical complications, vascular problems make up 2.8%. Renal artery stenosis (0.4%), renal artery thrombosis (0.4%), and renal vein thrombosis (0.9%) are among the stenotic or thrombotic sequelae (0.1 percent). In (1.9 percent), hemorrhagic problems were seen (58). They also observed a strong correlation between hemorrhagic problems and grafts with many renal arteries. The next biopsy revealed acute tubular necrosis, which was substantially correlated with stenotic, thrombotic, and hemorrhagic consequences. However, Ghazanfar A et al(59) noted that while vascular issues only account for 5-10% of all post-transplant complications, they may sometimes be the reason for graft failure.

Iatrogenic stenosis, which is produced by scarring due to the explanation, clamping, and/or anastomosis of the vessel with the iliac artery axis, affects the anastomosis site in roughly half of all TRAS patients. Less often, the artery may be stenotic throughout, or even in numerous segments. The stenosis in these situations is often brought on by catheter-related injury to the intima during the cold ischemia phase, but it may also be brought on by twisting and/or kinking after surgical insertion (60). The most frequent vascular complication, renal artery stenosis, affects 3 to 23% of all transplants (61). Therefore, thorough monitoring of urine output, serum creatinine, and Color Doppler ultrasonography were all part of early detection in our research.

A noninvasive imaging technique called colour duplex ultrasonography (CDUS) has been recommended for screening severe TRAS (62). In a study by Shruti Gandhi et al. (63), it was shown that the Post-PSV ratio is the most accurate criterion for determining the presence of severe renal artery stenosis in patients with end-to-side arterial anastomosis. Peak systolic velocity (PSV) measurements are used to determine the extent of arterial stenosis in the graft (64). However, kinking or stretching of the renal artery might result in erroneous acceleration (65). Peak systolic velocity of 200 cm/s in the major renal artery in an allograft and a resistive index of less than 0.50 indicate significant stenosis there (65).

In our research, we routinely conducted CDUS for all instances by the seventh postoperative day before discharge as long as the recipient had appropriate follow-

up procedures, such as regular urine output and a declining serum creatinine level that eliminated ATN. With the exception of seven instances where ATN was suspected, immediate CDUS testing confirmed that all transplant components were properly perfused. All patients were examined according to the same procedure, which began with the external iliac artery PSV measurement, was then evaluated in the primary graft artery, and finally in the auxiliary graft artery. The external iliac artery had an average flow rate of 146 cm/s, the primary graft artery of 149 cm/s, and the auxiliary graft artery of 148 cm/s. Despite having normal other parameters, only one instance was shown to have intra graft vascular dysfunction by CDUS. Therefore, diagnostic MRA is planned and revealed patent graft booth arteries.

Although there is a danger of contrast-induced nephropathy, some series claim that diagnostic angiograms may be essential. However, renal scintigraphy and angiography are often no longer required for ruling out serious vascular abnormalities, which is also detrimental to our nephrology and urology team. Beckmann JH et al. (66) execute an immediate modification of the procedure in the event of any issues or uncertainty. This procedure is also used by our surgical team to treat severe vascular issues, such as those that were present in two of the study's patients that were indicated by an abrupt drop in urine output and urgent CDUS findings of intra-graft vascular dysfunction. These instances were not included in our analysis because the anastomosis was immediately explored and revised once the graft was properly flushed.

However, other studies believe that US has technological limitations, operator reliance, and low anatomical (vascular) detail (67). Others are uncomfortable using MRI in transplant patients because of the danger of nephrogenic systemic fibrosis (NSF), particularly in those with impaired renal function (68). The danger of NSF brought on by gadolinium-containing contrast medium (69) has led to recent discussion over the possibility that MRI may no longer be the best investigation for these individuals. Additionally, the administration of modest volumes of CM is related with the risk of CIN and may result in renal failure because of the nephrotoxicity of iodinated CM and the danger of CIN (contrast induced nephropathy) (70).

Conclusions

Donors having a second renal artery supply did not take relative contraindication into consideration. The warm and total ischemia times are decreased by auxiliary graft artery sequential anastomosis. The auxiliary lower polar graft artery may be implanted in the internal iliac artery, which is a suitable option. The lower polar artery's risk of kinking and blood turbulence is decreased by the end-to-side anastomosis approach. In addition to being affordable, colour doppler ultrasonography provides a reliable way to assess the anastomosed graft vasculature.

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