Long-Term Clinical Outcomes of Patients with no-significant of Transplanted Renal Artery Stenosis

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Research Article

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Abstract

Background: Transplant Renal Artery Stenosis (TRAS) is the main vascular complication of kidney transplantation. For research and treatment purposes, several authors consider critical renal artery stenosis to be greater than 50%, and percutaneous intervention is indicated in this scenario. However, there are no reports in the current literature on the evolution of patients with less than 50% stenosis.

Method: Retrospective study includes data from all patients that were submitted to kidney transplantation and were suspected TRAS after transplantation with stenosis under 50% independent on age, who were referred for angiography at a single center between January 2007 and December 2014.

Results: During this period, 6,829 kidney transplants were performed at Hospital do Rim, 313 of them had clinical suspicion of TRAS and 54 were those who presented no-significant stenosis. The average age was 35.93 years old, the predominant gender was male and most individuals (94.4%) were submitted to dialysis before transplantation. Transplants, in most cases in this group, occurred from a deceased donor, 66.7%. The time between transplantation and angiography was less than one year in 79.6% of patients and all presented no-significant TRAS. Creatinine levels, Systolic Blood Pressure, Diastolic Blood Pressure and the glomerular filtration rate improved over the long term. The outcomes found were death and renal loss.

Conclusion: Age, sex and ethnic group of patients are factors that did not interfere with the frequency of renal artery stenosis. The outcomes showed that in the long term most patients evolve well, and have improved quality of life and kidney function, although there are cases of death and kidney loss.

1. Background

Transplant Renal Artery Stenosis (TRAS) is the main vascular complication of kidney transplantation[1]. The incidence of TRAS occurs between the 3rd month and the 2nd year after transplantation and varies from 1 to 23% depending on the diagnostic techniques and definitions used[2], although it can appear at any time, with refractory hypertension and / or dysfunction of the graft in the absence of rejection, ureteral obstruction or infection[3]. The factors attributed to TRAS may be perfusion of the clamp, incorrect suture technique or fibrotic inflammation to the suture material[4], or graft rejection, cytomegalovirus (CMV) infection and the graft from a deceased donor[5,6], the latter two being controversial factors in the literature[7].

TRAS diagnosis is carried out through several exams, as just evaluating clinical parameters does not guarantee reliability when monitoring renal perfusion. Thus, it is necessary to evaluate clinical manifestations in addition to complementary exams, such as serum creatinine, refractory hypertension, Doppler ultrasonography (US Doppler), angiotomography and angioresonance[8].

This pathology is associated with a higher cardiovascular risk and increased mortality[9,10]. For research and treatment purposes, several authors consider critical renal artery stenosis to be greater than 50%[11,12], and percutaneous intervention is indicated in this scenario. However, there are no reports in the current literature on the evolution of patients with less than 50% stenosis.

2. Methods

2.1- Patient selection and study design

This was a retrospective study approved by the local research ethics committee. Between January 2007 and December 2014, 6,829 kidney transplants were performed at Hospital do Rim. Patients with suspected TRAS due to refractory hypertension, renal dysfunction and/or increased PSV above 200 cm/s were referred to angiography. Patients with less than 50% stenosis were followed for a long period. Patients with lost follow-up were excluded from the analysis.

2.2- Data acquisition

Demographic and clinical data were collected from medical records. Procedure data were collected from our lab database. We used REDCap electronic data capture tools hosted at HSP – UNIFESP (13, 14). REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for data integration and interoperability with external sources.

2.3- Study endpoints

Primary outcomes were defined as all-cause mortality and allograft survival. Allograft loss was defined by the need for permanent dialysis, as documented by the renal transplant team notes.

Secondary outcomes were defined as serum creatinine (SCr), estimated glomerular filtration rate (eGFR) by Cockcroft-Gault, systolic blood pressure (SBP), and diastolic blood pressure (DBP), with 1 month and 1 year post-arteriography.

2.4- Statistical analysis

We used multiple imputations (*mice* package in R) to handle missing values (MV). We used a predictive mean matching model for numeric variables, logistic regression (logreg) for binary variables (with 2 levels) and Bayesian polytomous regression (polyreg) for factor variables (>= 2 levels). We did not impute missing values for the clinical outcomes.

Normally distributed data were presented as mean ±SD and skewed data as median [interquartile range (IQR)]. Normality of distribution and variances were checked using histograms, Kolmogorov-Smirnoff test, normal probability plots and residual scatter plots. Chi-square or Mann-Whitney, or two-tailed t-tests were used for comparison of baseline data.

Statistical analyses included a series of logistic regression models to predict the combined endpoint of death, kidney loss or retransplantation as main endpoint, using the odds ratio and 95% confidence intervals to estimate relative risk. Our regression models were built by using a stepwise approach, limiting to 2 to 3 variables per step or per model.

We selected variables with highest partial R^2 for respective outcome among those with high collinearity (inter-variable R^2 > 0.25 or variance inflation factor > 10). P-values<0.05 were considered as statistically significant. Analyses were carried out using R[v4.0.0].

3. Results

Characteristics of patients

6,829 kidney transplants were performed at Hospital do Rim, 313 of them had clinical suspicion of TRAS and 54 patients had no-significant stenosis (Table 1). The age of this group ranged from 14 to 68 years old. The predominant gender was male; most individuals were submitted to dialysis before transplantation with an average time higher than 2 years. The diagnosis of hypertension was found in most of the patients and all of these use medication for control and treatment, with 35% using two associated medications. The most common CKD was diabetic nephropathy and glomerulonephritis. Transplants occurred, mostly, from a deceased donor, and only one of these was undergoing retransplantation.

The patients in this study mostly use the following immunosuppressive regimen: Tacrolimus, Azathiopine and Prednisone, with the use of prednisone appearing in all patients in the study.

Angiographic data

The time between transplantation and angiography was less than one year in 79.6% of patients, and of the 54 studied, all presented no-significant TRAS, and all were submitted to US Doppler. From these patients, only 3.7% was the PSV value within normal parameters of up to 200 cm / s. The patients who underwent Angio TC, Angio RM, Angio 2D and Angio 3D are shown in table 2. Most patients have a degree of stenosis in 30%.

Laboratory tests and parameters.

Scr improved over a year when comparing creatinine before angiography and after one year of angiography, there were 11% more patients within normal values (Table 3).

In the case of SBP, their average values over a year were improved. In addition, with one month and after one year from angiography, a great number of patients presented a drop in SBP values. While diastolic blood pressure had the same improvement over the time (Table 3).

As for the eGFR, an improvement was noted one month after the angiography, but after one year there was an increase in these values, and with this, fewer patients within the normal range of the glomerular filtration values.

Mild clinical outcomes

There was a general increase in the number of patients using medications to treat hypertension before and after angiography. However, some of the patients experienced a decrease in the amount of medication they use (Table 4).

Clinical outcomes.

The outcomes presented were renal loss and death, all due to cardiovascular causes. Retransplantation was not found in any of the cases, and the remainder had no long-term outcome (Table 5).

From the patients who died, all were male, with an average age of 53.5 years old. All were submitted to hemodialysis. 75% had a diagnosis of hypertension using medication. 50% of them had diabetic nephropathy as the main underlying disease. All were recipients of deceased donors. The immunosuppressive regimen was Tacrolimus, Mycophenolate, Prednisone or Ciclosporin, Azathiopine, Predinisone.

All of them had suspected TRAS and performed US Doppler with 100% of the PSV values above 300 cm / s. The degree of stenosis in 50% of the individuals was in the 40% range, and the places of stenosis were in 50% of the patients in the renal artery ostium and in 50% in the renal artery body. Only 25% underwent a new US Doppler after angiography, with a PSV value above 300 cm / s. All patients continued to use medication to control and treat hypertension after angiography. The majority of patients presented better in SBP, DBP, creatinine levels and glomerular filtration rate over one year.

From the patients who presented renal loss outcome, 81.8% were male, with an average age of 34.2 years old. 100% of these undergo hemodialysis. The underlying disease found in the majority was glomerulonephritis. 90.9% of patients reported a positive diagnosis of hypertension, and 100% of them use medication to control and treat the disease. The type of donor was mostly from deceased ones with 90.1%, and the causes of death were 50% trauma, 30% neurological disease and 10% cardiovascular disease. The ISS scheme of the majority was Tacrolimus, Mycophenolate, Prednisone. In this group, 100% of patients had suspected TRAS, as well as Doppler ultrasonography and only 2 patients had PSV within the normal value, that is, up to 200 cm / s. Most had a degree of stenosis in 30%. 36.4% of patients underwent a new US Doppler and all PSV remained within normal values. All patients use medication to control

hypertension after transplantation and angiography. When we analyzed the amount of medication to treat hypertension before and after angiography, which this group of patients uses, we noticed that there was a decrease in the number of associations. Before, it was well known that patients used two or three combinations of drugs, and after angiography this value dropped to one or two associations. In this group, only four patients showed improvement in creatinine levels. SBP, DBP and glomerular filtration rate also improved in a few patients.

4. Discussion

TRAS is the main vascular complication of kidney transplantation Controversies in the literature about the factors that trigger stenosis in the artery of the transplanted kidney are numerous, and among them we can find type of donor, time between transplant and stenosis, even the technique used for arterial anastomosis[13]. In 2015, a study showed that the association of the first lesions with complications of the surgical technique and of the graft is related to the pathophysiology and temporality of the lesions, so that TRAS becomes, for patients with renal graft, risk factors and clinical signs such as: worsening renal function, stenosis, increase in antihypertensive drugs, high PSV value, among others, an important vascular complication[14,15]. In this study, 54 patients were analyzed and all of them presented non-significant stenosis, that is, less than 50%.

Previous studies of patients with significant stenosis, that is, over 50% showed that there was a divergence in the average age, one with an average of 55 years old, the other with an average of 37 years old, therefore there is no relationship between age and degree of stenosis[16,17] , since this study had an average of 35.93 years old. However, these previous studies showed that the patients' gender was mostly male, corroborating the present study, in which the majority, 81.5% of the individuals, were also male [16-18]. Dialysis is recommended for patients with end-stage renal disease (ESKD)[19], which is the case of this study, in which the entire number of patients was submitted to some type of dialysis or conservative treatment, corroborating the findings.

In studies with significant stenosis, a diagnosis of systemic arterial hypertension was observed, in spite of the use of medications being superior to three associated types. The systolic averages found in these studies were 170 ± 30 mmHg and diastolic 105 ± 15 mmHg. After follow-up and endovascular treatment, there was an improvement in pressure and the averages became 120 ± 20 mmHg for systolic and 75 ± 15 mm Hg for diastolic, and a decrease for up to two associated medications[16]. The averages in the patients in this study were considerably lower than the averages in the patients in studies with significant stenosis. Before and after angiography, the highest number of associated medications was two, and in the interval before and after angiography, this value increased by 6%. After transplantation, several conditions and etiologies exist for the onset or worsening of SAH such as: toxicity of immunosuppressive drugs, graft rejection, recurrence of the original kidney disease, etc. Among these conditions is also stenosis of the renal artery, which is responsible for hypertension in 10% of transplant recipients, but has great potential for cure[20-26].

The Brazilian Society of Nephrology states glomerulonephritis (23.5%), hypertensive nephrosclerosis (24.1%) and diabetes mellitus (16.6%) as the main causes of chronic renal failure (16.6%)[19,27]. Relating this to the study, the CKD categorized as indeterminate occurred in more than 35% of the studied patients, followed by glomerulonephritis (16.7%), diabetic nephropathy (14.8%) and hypertensive nephropathy (7.1%).

The origin of the transplanted organ is very varied and according to Associação Brasileira de Transplante de Órgãos (ABTO), on average 59% of transplants come from living donors and 41%, from deceased[27,28]. In 1998, in a study with 676 kidney transplants, Lopes *et al.*[29] reported an index of 1,63% of stenosis and that all the incidences of stenosis occurred in deceased donor transplants, while in the study by Mendes et al. most recipients received a donation from a living donor. In the present study, with a non-significant TRAS, the donor type was deceased donors in 66.7% of the evaluated cases. During the statistical analysis it was found that there was no relation between the type of donor and the condition of the patient having significant or not-significant stenosis of the renal artery. The tendency towards a lower number of stenosis, when using a deceased donor, may be attributed to the more frequent use of aortic patch[16].

In a study published by Medina[30] in 2017, it was observed that cyclosporine was replaced by tacrolimus and azathiopine by mycophenolate over the years of his research, and also reveals that in the first years, the combination of cyclosporine with azathiopine and prednisone was predominant. However, the use of tacrolimus has increased over time, and that association with azathiopine was found in higher percentage than those with mycophenolate. This corroborates with this study, in which all immunosuppressive associations were observed with prednisone, and drug combinations involving tacrolimus were more used in patients than those involving cyclosporine. In the choice between azathiopine and mycophenolate to associate with other immunosuppressive, azathiopine appears in a greater number of patients, regardless the association. In this study, the most common association of immunosuppressive was 37% of kidney transplant recipients with tacrolimus, azathiopine and prednisone. Patients with high immunological risks and retransplants use mainly the scheme involving tacrolimus, mycophenolate and prednisone, this is due to the possible reduction observed in the incidence of treated acute rejection[31]. Despite the use of these immunosuppressants to decrease the incidence of treated acute rejection, it should also be taken into account that this scheme improves patient and graft survival[32,33]. When we analyzed, in this study, the patients who presented the outcome of renal loss, it was possible to notice that their immunosuppressive regimens were mostly tacrolimus, mycophenolate and prednisone, while the patients who presented the outcome died mostly with another immunosuppressive regime.

The time between transplantation and angiography occurred in less than a year, as in other studies, but with patients with significant stenosis, therefore, there was no relationship between the time and the degree of stenosis of patients[7,13].

The Doppler echo exam is chosen for recipients with graft dysfunction and the increase in peak velocity suggests that the vascular flow is compromised, and that, when stenosis is suspected, it is necessary to perform angiography[20,34,35]. Thus, the gold standard for definitively diagnosing stenosis is angiography, as it confirms the lesion that ultrasound has identified, and thus it is possible to plan the therapeutic approach and ascertain the need for intervention[11,21,34,35]. In this study, all patients underwent Doppler examination and had suspected stenosis, and after angiography, a non-significant stenosis < 50% was suggestive.

In order to diagnose TRAS, cut-off values are not homogeneous in the literature, with the most consensual values for direct parameters being a PSV > 180-200 cm/s[36-38]. In this study, the PSV values were considered normal up to 200 cm/s. And only two out of 54 subjects had PSV within normal values prior to angiography. Of the patients who had high PSV, the highest percentage was in the range of 201 to 400 cm/s, considering that three patients studied had PSV greater than 601 cm/s. This shows that despite high PSV, patients with non-significant stenosis had PSV closer to normal levels. After angiography, 20 patients underwent a new Doppler ultrasonography, seven of whom had SPV within normal limits. In the United States, in clinical practice, it is common to use CT angiography and MRI angiography, whereas in Europe these methods are used only when, after renal Doppler, doubts about the diagnosis persist, or when there are strong hypotheses, for example, patients with multiple risk factors, taking into account all contraindications inherent to these procedures[22,34-37]. In this study, Angio-CT was performed in less than 40% of patients, while Angio-MRI was not performed.

Stenosis is considered significant when it compromises more than 50% of the arterial lumen and the therapeutic approach to treatment depends on the degree of stenosis also on its location. In cases of mild stenosis, that is, cases where blood pressure is controllable with medication and the creatinine level remains stable and < 3 mg/dl, conservative treatment is commonly used[11,12]. After evaluating and performing tests such as US Doppler, Angio-CT among others, it was found that the degree of stenosis in this study ranged from 10% to 46%, being considered, therefore, not significant degrees of stenosis, and therefore these patients have not undergone intervention.

Renal graft dysfunction of vascular etiology is usually secondary to stenosis of the transplanted renal artery. However, high levels of serum creatinine and hypertension may also be present in patients with stenosis[39]. In these patients, creatinine levels returned to values considered normal for a renal transplant patient, that is, values at the maximum limit of normality or slightly increased. CKD can be classified according to the glomerular filtration rate, in five stages[28]. Other parallel studies are unanimous in showing that the glomerular filtration value > 90 ml/min/1.73m^2 is the best parameter associated with prolonged organ survival[40-42]. Renal function should be monitored using the glomerular filtration rate estimated by the Cockroft-Gault equation[43-46]. In these cases, the measurement of serum creatinine is not recommended because there is no linear relationship between plasma creatinine level and glomerular filtration rate[45,46]. Some studies of converting the therapeutic regimen of cyclosporine and azathiopine to tacrolimus and mycophenolate, or the use of mycophenolate and the reduction of cyclosporine doses have shown a significant improvement in the glomerular filtration rate[47-51]. These data are in accordance with this study, since more patients used the tacrolimus and mycophenolate regimen, and showed an improvement in the glomerular filtration rate.

The outcomes found in this study varied mainly between renal loss and death, while the other patients continue to evolve well with transplantation and angiography. Comparing both groups of outcome, death and renal loss, it was found that the average age of patients who died was high compared to those who had kidney loss. One study[52] showed that the average age of patients who died after kidney transplantation was over 40 years old and that death after transplantation occurred in 10.6% of the studied patients. The patients who had kidney loss was 20.9%. These data corroborate with the study showing that the death rate for patients undergoing transplantation is relatively low and that the age of these patients is over 40 years old. However, when the average survival time of these individuals was evaluated, in the study previously mentioned, it was 14.4 months, while in the present study the survival time was much longer.

The percentage of patients with renal loss was significant in the study mentioned and in the present study with 20,7%, and the average age of these patients was over than 30 years old.

In conclusion, age, sex and ethnic group of patients are factors that did not interfere with the frequency of renal artery stenosis.The outcomes showed that in the long term, death occurs in patients older than patients with the outcome of renal loss. Even so, most patients progress well, and have improved quality of life and kidney function.

This study did not make it possible to establish significant associations between non-significant stenosis, that is, <50% and factors such as: DM, SAH and other underlying diseases, as well as it did not make it possible to associate EART <50% with graft type, time between transplant and angiography, degree of stenosis, time on dialysis or its type, SPV values, levels of creatinine or glomerular filtration rate, SBP and DBP. Thus, further studies are necessary for this scope, because, on non-significant stenosis, that is, < 50%, there is no previous literature.

In addition, this study has limitations for it is a retrospective study, there are no previous literatures on patients with non-significant stenosis and the search was performed in a single center.

List Of Abbreviations

BMS, bare metal stent; CMV, cytomegalovirus; CIT, cold ischemia time; DBP, diastolic blood pressure; DES, drug-eluting stent; DGF, delayed graft function; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; ESRD, end-stage renal disease; PTA, percutaneous transluminal angioplasty; PSV, peak systolic velocity; SBP, systolic blood pressure; SCr, serum creatinine; TRAS, transplant renal artery stenosis; US, ultrasonography.

Declarations

Ethics approval and consent to participate: Ethic Committee of Federal University of São Paulo (UNIFESP) approved the study reference number 4.098.877. This study was conducted in accordance with Good Clinical Practice, EU guidelines (EN 540) and any local regulations and the Helsinki Declaration. All medical ethics rules were followed throughout the research. The need of the informed consent was waived by the Ethic Committee of Federal University of São Paulo (UNIFESP).

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Henry Campos Orellana: data acquisition.

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Hélio Tedesco Júnior: Study design, writing and revision of the manuscript.

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Adriano Henrique Pereira Barbosa: Study design, data acquisition and contributor in writing, review and correction the manuscript.

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Tables

Table 1. Characteristics of patients

N		54
Age (years) (mean (SD))		35.93 (15.96)
Gender (%, women)		10 (18.5)
Whites (%)		22 (40.7)
Weight (kg, D0) (mean (SD))		64.61 (18.32)
Height (cm, D0) (mean (SD))		168.50 (11.39)
BMI (kg/m2) (mean (SD))		22.39 (4.83)
Time on dialysis (months) (mean (SD))		33.10 (25.88)
Type of dialysis (%)		
	Hemodialysis	49 (96.1)
	Peritoneal dialysis	1 (2.0)
	Conservative treatment	1 (2.0)
HLA class (%)		
	Ident (I)	27 (54.0)
	Hapto (II)	6 (12.0)
	Dist (III)	6 (12.0)
	CAD	11 (22.0)
Hypertension (%)		43 (79.6)
Diabetes mellitus (%)		15 (27.8)
Dyslipidemia (%)		5 (9.3)
Smoking (%)		3 (5.6)
EBV serum (% positive)		5 (13.9)
CMV serum (% positive)		47 (90.4)
CMV prophylaxis (%)		17 (32.1)
Prior Hypertensive nephropathy (%)		9 (16.7)
Prior Diabetic nephropathy (%)		12 (22.2)
Prior Polycystic nephropathy (%)		3 (5.6)
Prior Glomerulonephritis (%)		10 (18.5)
Prior other diagnoses (%)		6 (11.1)
Prior unknown cause of CKD (%)		19 (35.2)
Other diseases (%)		
	NA	49 (90.7)
	Indeterminate	1 (1.9)
	Repeated Urinary Infection	1 (1.9)
	Renal Malformation	1 (1.9)
	Repeating Pyelonephritis	1 (1.9)
	Posterior Urethral Valve	1 (1.9)
Alive donor (%)		18 (33.3)
Deceased donor (%)		36 (66.7)
Panel (%) (mean (SD))		7.23 (18.69)
Second Transplantation (index Tx)		1 (1.9)
Time since transplantation (months) (median [IQR])		5.00 [3.00, 9.00]
TAV (median [IQR])		30.00 [25.00, 37.00]
TIF (mean (SD))		17.67 (12.14)
Total cholesterol (mg/dL) (mean (SD))		170.93 (46.93)
HDL-C (mg/dL) (mean (SD))		43.85 (11.50)
LDL-C (mg/dL) (mean (SD))		106.45 (46.22)
Cause of death (donor) (%)		
	NA	19 (35.2)
	CV disease	5 (9.3)
	Neurologic disease	17 (31.5)
	Trauma	13 (24.1)
Type of graft (%)		
	NA	14 (25.9)
	Gregoir	32 (59.3)
	Politano	4 (7.4)
	Ureteropielo	4 (7.4)
Blood type (%)		
	NA	7 (13.0)
	A	15 (27.8)
	AB	3 (5.6)
	B	7 (13.0)
	O	22 (40.7)
RH factor = + (%) (n = 16)		16 (100.0)
Blood transfusion		17 (33.3)
Baseline Meds		
Anti-Hypertensive Meds at baseline (%)		43 (100.0)
ACEi at baseline (%)		17 (31.5)

ARB at baseline (%)	6 (11.1)
Beta-blocker at baseline (%)	21 (38.9)
Diuretic at baseline (%)	10 (18.5)
Vasodilator at baseline (%)	14 (25.9)
Calcium channel blockers at baseline (%)	25 (46.3)
Central alpha-antagonist at baseline (%)	5 (9.3)
Insulin at baseline (%)	10 (18.5)
Oral hypoglycemic meds at baseline (%)	5 (9.3)
Hypolipidemic meds at baseline (%)	3 (5.6)
Simvastatin at baseline (%)	2 (3.7)
Atorvastatin at baseline (%)	0 (0)
Rosuvastatin at baseline (%)	0 (0)
Post-Tx smoking	2 (3.9)
Treatment for rejection	18 (34.6)
ISS Tacrolimus	36 (70.6)
ISS Mycophenolate	18 (35.3)
ISS Prednisone	50 (98.0)
ISS Cyclosporine	15 (29.4)
ISS Azathioprine	34 (66.7)

Table 2.

Doppler / Angiography measures	
Suspected TRAS	53 (100.0)
US Doppler	52 (100.0)
A_angio_TC (mean (SD))	28.20 (13.86)
Stenosis A 3D (median [IQR])	30.00 [30.00, 30.00]
Luminal reduction (%) (mean (SD))	29.35 (7.69)
Translesional gradient (mean (SD))	11.31 (5.76)
Stenosis rate (mean (SD))	30.06 (9.13)
Angio TC	15 (31.2)
Angio RM	0 (0)
Angio 2D	48 (96.0)
Angio 3D	26 (52.0)
Any stenosis (%)	54 (100.0)
Stenosis ≥ 30% & < 50% (%)	40 (74.1)
Stenosis at iliac aa	1 (1.9)
Stenosis at renal artery ostium	31 (57.4)
Stenosis at RA body	22 (40.7)
Stenosis at RA branches (%)	0 (0)
Stenosis at polar aa (%)	0 (0)
Stenosis type (concentric) (%)	8 (14.8)
Stenosis type (eccentric) (%)	0 (0)
Stenosis type (diffuse) (%)	1 (1.9)

Table 3.

Substitute Outcomes (follow-up lab parameters)	
Creatinine at baseline (mg/dL) (median [IQR])	1.68 [1.44, 2.24]
Creatinine at 1 month (mg/dL) (median [IQR])	1.73 [1.43, 2.19]
Creatinine at 1 year (mg/dL) (median [IQR])	1.56 [1.31, 2.00]
Delta Creatinine at 1 month (mg/dL) (median [IQR])	0.05 [-0.22, 0.18]
Delta Creatinine at 1 year (mg/dL) (median [IQR])	-0.18 [-0.39, 0.10]
SBP pre-arteriography (mmHg) (mean (SD))	144.00 (22.98)
SBP at 1 month (mmHg) (mean (SD))	136.98 (18.74)
SBP at 1 year (mmHg) (median [IQR])	130.00 [120.00, 140.00]
Delta SBP at 1 month (mmHg) (mean (SD))	-7.34 (25.42)
Delta SBP at 1 year (mmHg) (mean (SD))	-9.89 (34.45)
DBP pre-arteriography (mmHg) (mean (SD))	86.88 (15.00)
DBP at 1 month (mmHg) (mean (SD))	81.94 (10.80)
DBP at 1 year (mmHg) (mean (SD))	80.44 (10.50)
Delta DBP at 1 month (mmHg) (mean (SD))	-4.86 (17.11)
Delta DBP at 1 year (mmHg) (mean (SD))	-5.18 (18.04)
VPS (mean (SD))	395.10 (113.02)

VPS post (median [IQR])	256.50 [137.75, 297.50]
Delta VPS (mean (SD))	-207.70 (171.75)
GFR at baseline (mean (SD))	44.92 (31.94)
GFR at 1 month (mean (SD))	44.92 (28.92)
GFR at 1 year (mean (SD))	48.50 (31.98)
Change in GFR at 1 month (median [IQR])	0.00 [-5.00, 2.00]
Change in GFR at 1 year (median [IQR])	0.50 [-2.75, 10.00]
Drop >0.1 mg/dL in Creatinine at 1 month	29 (53.7)
Drop >0.1 mg/dL in Creatinine at 1 year	29 (53.7)
Any drop in SBP at 1 month	27 (50.0)
Any drop in SBP at 1 year	21 (38.9)
Any drop in DBP at 1 month	23 (42.6)
Any drop in DBP at 1 year	21 (38.9)
Any drop in VPS	13 (24.1)

Table 4.

Soft Clinical Outcomes	
Suspected restenosis	1 (1.9)
Clinical follow-up	50 (96.2)
Anti-hypertensive meds pre (mean (SD))table 3	2.28 (1.01)
Anti-hypertensive meds post (mean (SD))	2.16 (1.08)
Absolute change in anti-hypertensive meds (mean (SD))	0.05 (0.99)
Any drop in anti-hypertensive meds	8 (14.8)

Table 5.

Hard Clinical Outcomes	
New graft (new transplantation)	0 (0)
Renal loss	12 (22.2)
Death	4 (7.4)
CV Death	4 (7.4)
Compound outcome	16 (29.6)