Characteristics and medium-term outcomes of Takayasu arteritis–related renal artery stenosis: analysis of a large Chinese cohort

Running head: Renal artery stenosis

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Abstract

Objective. To investigate the characteristics of patients with Takayasu arteritis (TA)-related renal artery stenosis and identify the predictors of medium-term adverse outcomes.

Methods. Data for 567 patients registered in a large prospective observational cohort-the East China Takayasu arteritis cohort-up to April 30, 2019, were retrospectively analyzed.

Results. Renal artery stenosis was confirmed in 172/567 (30.34%) patients, with left renal artery involvement seen in 73/172 (42.44%) patients. Renal insufficiency at presentation (HR = 2.37, 95% CI: 1.76-15.83, p = 0.03), bilateral renal artery involvement (HR = 6.95, 95% CI: 1.18-21.55, p = 0.01), and severe (>75%) stenosis (HR = 4.75, 95% CI 1.08-11.33, p = 0.05) were predictors of adverse outcomes. A matrix model constructed using three parameters (renal function, stenosis severity, and bilateral renal artery involvement) could identify three risk groups. Revascularization was performed for 46/172 (26.74%) patients. Patients without preoperative treatment had higher rate of restenosis (44.44% vs. 15.79%, p < 0.01) and hypertension deterioration (25.93% vs. 10.53%, $p < 0.01$) after the procedure. Non-receipt of preoperative treatment (HR = 6.5, 95% CI: 1.77-32.98, p = 0.04) and active disease at revascularization (HR = 4.21, 95% CI 2.01-21.44, p = 0.04) were independent predictors of adverse outcomes after revascularization.

Conclusion. Patients with TA-associated renal artery stenosis and uncontrolled or worsening hypertension or/and renal function may benefit from revascularization. Those who have received preoperative treatment may have more favorable revascularization outcomes. Prognosis appears to be poorer for patients with renal insufficiency at presentation, bilateral artery involvement, and severe stenosis.

Introduction

Takayasu arteritis (TA) is a chronic, large-vessel vasculitis that primarily affects the aorta and its main branches (1-3). The incidence of renal artery stenosis in TA is 20%–60% according to previous reports (4-6). In patients under the age of 40 years, TA is responsible for 60.5% of cases of renal artery stenosis (7) and, among Asian TA patients, almost half have renal artery involvement (8). Renal artery stenosis can cause refractory hypertension, renal function disturbance, and premature death (8-10). Early recognition and treatment of TA-related renal artery stenosis could help in preventing long-term adverse outcomes.

Treatment for TA-related renal artery stenosis includes pharmacotherapy and revascularization procedures. Glucocorticoids, immunosuppressants, and biological agents are used to control systemic and vascular inflammation, and prevent disease progression and organ damage (11, 12), while antihypertensive drugs are used to control blood pressure and prevent ischemic symptoms. Revascularization procedures may be needed to treat severe stenosis, malignant hypertension, or persistent refractory hypertension (13, 14). The results of vascular interventions for TA have not been consistent in previous studies, with some authors reporting a high rate of restenosis and others demonstrating good long-term arterial patency after treatment (15-17). A major limitation of these earlier studies was that they did not evaluate how pharmacotherapy influenced the long-term outcomes of vascular interventions (15-17).

The specific characteristics of patients with TA-related renal artery stenosis, the effect of revascularization procedures on prognosis, and the risk factors for adverse outcomes after the vascular intervention have not been fully investigated in Chinese populations. This study was designed to investigate: 1) the characteristics of Chinese patients with TA-related renal artery stenosis; 2) the predictors of medium-term adverse outcomes in these patients; and 3) the predictors of adverse outcomes in the subgroup undergoing revascularization procedures.

Materials and Methods

Patients

This study was based on a prospectively maintained observational cohort-the East China Takayasu arteritis (ECTA) cohort. The ECTA (NCT03893136) was established in 2010 in our center, Zhongshan Hospital, which is a tertiary-care hospital affiliated to Fudan University, Shanghai, China. For this retrospective study, we included all 567 patients registered in the ECTA up to April 30, 2019. All patients had been diagnosed with TA by rheumatologists using the 1990 American College of Rheumatology (ACR) criteria (18). The diagnoses were confirmed by whole-body enhanced magnetic resonance angiography (MRA), computed tomographic angiography (CTA), or vascular ultrasound (if angiography could not be performed because of allergy to iodine or other contraindications).

This study was performed in accordance with the tenets of the Helsinki Declaration and its amendments. The study protocol was approved by the Ethics Review Board of Zhongshan Hospital (B2013-115). Written informed consent was obtained from all patients.

Medications

At our center, medical therapy for TA has two phases: an induction phase and a maintenance phase. In the induction phase, oral prednisone is started at a dose of 0.8–1.0 mg/kg/day; after 4 weeks, the dose is tapered gradually over 5 months to a maintenance dose of 0.1–0.2 mg/kg/day. Along with prednisolone, an immunosuppressant (cyclophosphamide, methotrexate, azathioprine, leflunomide, or mycophenolate mofetil) or a biological agent is also administered; the choice of immunosuppressant versus biological agent is at the physician's discretion. The dosages used are as follows: cyclophosphamide, 0.5–0.75 g/m^2 (usually 0.8 g) intravenously every 4 weeks; methotrexate, 10–15 mg/week orally; azathioprine, 50–100 mg/day orally; leflunomide, 10–20 mg/day orally; and mycophenolate mofetil, 1–2 g/day orally. Induction treatment lasts for 6 months. If active disease is still present at the end of 6 months, the prednisolone dose is adjusted and a change of the immunosuppressant drug is considered. Maintenance therapy is with methotrexate (10–15 mg/week orally), azathioprine (25–50 mg/day, orally), leflunomide (10–20 mg/day, orally), or mycophenolate mofetil (1–1.5 g/day, orally).

Antihypertensive drugs are used to control blood pressure, with combinations of two or more drugs used when necessary. The drugs include calcium channel antagonists (CCB), angiotensin-converting enzyme inhibitors (ACEI) or angiotensin receptor blockers (ARB), β-blockers, α-blockers, diuretics, and others (e.g., clonidine).

Disease activity assessment and follow-up.

Data recorded up to April 30, 2019, were collected for analysis. Demographic factors, clinical characteristics, laboratory findings, imaging features, and follow-up data were noted. Estimated glomerular filtration rate (eGFR) was calculated using the chronic kidney disease epidemiology collaboration equation (19). Follow-up was conducted once a month during the induction period, and once every 3 months during the maintenance period. MRA or CTA was performed every 6 months to assess disease progression. Radioisotope renography was performed to evaluate renal dysfunction if necessary.

Disease activity was assessed using Kerr criteria (20), which include the following: 1) systemic symptoms (not due to other causes such as infection, tumor and so on); 2) erythrocyte sedimentation rate; 3) vascular ischemic symptoms or signs (e.g., weak pulse or pulselessness, vascular bruits, or asymmetric blood pressure); and 4) positive imaging results. Appearance of new symptoms or worsening of two or more criteria indicates active disease.

Definition of adverse outcomes

Renal insufficiency was defined as serum creatinine ≥130 µmol/L or eGFR ≤60 mL/min. Hypertension was defined as blood pressure ≥140/90 mmHg. Refractory hypertension was defined as blood pressure ≥160/90 mm Hg despite maximal doses of three antihypertensive drugs.

Severity of renal artery stenosis was categorized as <50%, 50%–75%, or >75% on MRA or CTA, as described in a previous study (21).

Adverse outcomes for patients with TA-related renal artery stenosis included: 1) persistent renal insufficiency at 6 months after diagnosis, or deterioration of renal function (≥20% increase in creatinine concentrations or ≥20% decrease in eGFR); 2) persistent refractory hypertension at 6 months or malignant hypertension; 3) congestive heart failure; and 4) TA-related death (e.g., death caused by severe arterial stenosis or aortic dissection. Adverse outcomes after renal artery revascularization procedures included: 1) restenosis; 2) ≥20% increase in blood pressure after the procedure; 3) ≥20% deterioration of renal function after the procedure; and 4) TA-related death.

Statistical analysis

Categorical variables were summarized as counts and percentages and compared between groups using the chi-square test. Continuous variables were summarized as means ± standard deviations (SD) or as medians with interquartile range (IQR), depending on the normality of the distribution, and compared using the *t*-test, Wilcoxon test, or Mann–Whitney test. Univariate logistic regression analysis was performed to examine the association of baseline factors with outcomes. Factors significantly associated (at $p < 0.10$) with poor outcome were entered into a Cox proportional hazards regression model to identify the independent predictors of adverse outcomes, and the hazard ratios (HR) and 95% confidence intervals (CI) were calculated. Using these results, a risk-prediction matrix was built that could be used to stratify patients according to risk of adverse outcomes. The ability of the model to predict adverse outcomes was assessed using receiver operating characteristic (ROC) curve analysis. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. Statistical analysis was performed using

SPSS 22.0 (IBM Corp., Armonk, NY, USA). Two-sided $p < 0.05$ indicated statistical significance.

Results

Patient characteristics

A total of 567 TA patients were included in this study. Median age at disease onset was 29 (22–38) years, and median age at diagnosis was 31 (22–38) years. The majority of patients were female (455/567, 80.25%). According to the 1996 Numano's classification system (22), the most common type was type V (234/567, 41.79%), followed by type II (147/567, 25.93%), type I (74/567, 13.05%), and type IV (63/567, 11.11%). Table 1 presents the characteristics of the patients.

Comparison of disease features between patients with and without renal artery involvement

Renal artery involvement was confirmed in 172/567 (30.34%) patients. Bilateral renal artery involvement was observed in 55/172 (31.98%) patients. While 12/172 (16.67%) patients had only renal artery involvement, the rest also had involvement of other arteries, e.g., left carotid artery (56/172, 34.30%), left subclavian artery (57/172, 33.14%), and abdominal aorta (51/172, 29.65%).

The group with renal artery involvement had a significantly lower proportion of female patients ($p = 0.04$) and a significantly lower prevalence of systemic symptoms ($p = 0.03$). The group had a significantly higher prevalence of hypertension ($p = 0.02$)- especially refractory hypertension ($p < 0.01$)-and a significantly higher prevalence of renal insufficiency ($p = 0.03$) (Table 1).

Risk factors for medium-term adverse outcomes in TA-related renal artery stenosis

The median follow-up period of patients with renal artery stenosis was 45 (3–78) months. During the follow-up, 46/172 (26.74%) patients suffered adverse outcomes: 17 patients had persistent refractory hypertension, 6 patients had malignant hypertension, 7 patients had persistent renal insufficiency, 4 patients had renal function deterioration, 7 patients had congestive heart failure, and 5 patients died due to TA-related causes (2 congestive heart failure, 1 malignant arrhythmia, 1 aortic dissection, and 1 acute myocardial infarction).

Patients with renal artery stenosis could be separated into three groups according to the severity of renal artery stenosis: <50% stenosis (n = 47), 50%–75% stenosis (n = 51), and >75% stenosis (n = 52). Table 2 presents a comparison of the characteristics of these three groups.

Supplementary Table 1 presents the results of logistic regression analysis of baseline factors. Cox proportional hazards regression analysis showed that renal insufficiency at presentation (HR = 2.37, 95% CI: 1.76–15.83, p = 0.03), bilateral renal artery involvement (HR = 6.95, 95% CI: 1.18–21.55, p = 0.01), and severe (>75%) stenosis (HR = 4.75, 95% CI: 1.08–11.33, p = 0.05) were independent predictors of adverse outcomes.

Using these parameters (i.e., baseline renal function, severity of renal artery stenosis, and presence of bilateral renal artery involvement), we built a risk-prediction matrix that could be used to stratify patients into different risk groups. ROC analysis showed satisfactory performance of the model: 89% sensitivity, 71% specificity, 82% PPV, and 88% NPV for predicting risk of adverse outcomes.

Comparisons of characteristics of patients with and without revascularization

A total of 46/172 (26.74%) patients underwent revascularization procedures.

Table 3 presents data for patients with and without revascularization. The revascularization group had significantly higher proportions of patients with renal insufficiency ($p = 0.03$), hypertension ($p = 0.04$), especially refractory hypertension ($p < 0.01$) and severe stenosis ($p < 0.01$).

Effect of preoperative therapy on outcomes of renal artery revascularization

A total of 65 renal artery revascularization procedures were performed in 46 patients (1.41 per person, range: 1–4). The procedures included percutaneous transluminal angioplasty (PTA; 40/65, 61.54%), stent implantation (16/65, 24.62%), autotransplantation (2/65, 3.08%), bypass surgery (3/65, 4.62%), and nephrectomy (4/65, 6.16%). The median follow-up after revascularization was for 34 (3–52) months.

According to whether or not glucocorticoid and immunosuppressant drugs were used, the patients undergoing revascularization procedures could be separated into two groups: the preoperative therapy group (n = 24) and the no preoperative therapy group (n = 41). In the preoperative therapy group, median duration of preoperative therapy was for 9 (1–15) months. In the no preoperative therapy group, all 41 patients underwent revascularization procedures before definite diagnosis of TA; the procedures were performed to control blood pressure or manage acute ischemic events. In both groups, blood pressure decreased immediately after revascularization. However, at 6 months after the procedure, the no preoperative therapy group showed a significant increase in blood pressure (Fig. 2 C–D). A similar pattern was observed in the changes in renal function in the two groups (Fig. 2 A–B). Restenosis rate was significantly higher in the no preoperative therapy group (41.46% vs. 16.67%, $p < 0.01$) during the first 2 years after revascularization (Fig. 3A).

Risk factors for adverse outcomes after renal artery revascularization

The risk factors for adverse outcomes after renal artery revascularization included renal insufficiency at presentation (OR = 1.87, 95% CI: 1.12–21.34, $p = 0.04$), refractory hypertension at presentation (OR = 2.06, 95% CI: 1.07–19.44, $p = 0.03$), active disease at the time of surgery (OR = 4.06, 95% CI: 1.42–21.78, $p = 0.03$), and non-receipt of preoperative therapy (OR = 7.4, 95% CI: 2.05–47.31, $p = 0.03$).

In Cox proportional hazards regression analysis the independent predictors of adverse outcome after revascularization were non-receipt of preoperative therapy (HR = 6.5, 95% CI: 1.77-32.98, p = 0.04; Fig. 3B); active disease at the time of surgery (HR = 4.21, 95%CI 2.01-21.44, p = 0.04); and severe stenosis (HR = 1.98, 95%CI 1.18-17.32).

Using these parameters (i.e., non-receipt of preoperative treatment, presence of active disease at the time of surgery, and severity of stenosis), we built a risk-prediction matrix that could be used to stratify patients into different risk groups. ROC analysis showed satisfactory performance of the model: 87% sensitivity, 69% specificity, 78% PPV, and 84% NPV for predicting risk of adverse outcomes after revascularization.

Discussion

This study was performed to determine the characteristics of Chinese TA patients with renal artery involvement and to identify the predictors of medium-term adverse outcomes. To our knowledge, this is the largest cohort of patients with TA-related renal artery stenosis.

In this study, renal artery involvement was seen in 30.34% patients, which is notably lower than the 48.92% reported in another Chinese study (8). Consistent with the earlier study, we found hypertension, especially refractory hypertension, and renal insufficiency to be significantly more common in patients with renal artery involvement. In our sample, systemic symptoms were uncommon in patients with renal artery involvement; this is an important finding since it suggests that diagnosis of TA may sometimes be delayed or missed. Thus, in patients with hypertension, especially in those younger than 40 years, an etiological diagnosis is essential, and TA-related renal artery stenosis should be ruled out.

Medium-term outcomes in patients with TA-related renal artery stenosis have been previously described in Korean (10) and Caucasian (23) populations. In the Korean study, bilateral lesions and renal functional impairment at presentation were significant adverse prognostic factors; this result is concordant with our findings. However, in the Caucasian population, medium-term non-renal and renal outcomes were favorable; no patient experienced end-stage renal disease or died. The different results in the latter study may be related to the relatively small sample size and short follow-up period, in addition to the ethnicity of the enrolled patients.

PTA was the most commonly used revascularization procedure (61.54%) in our sample; this is consistent with earlier reports (24-26). Non-receipt of preoperative treatments and active disease at the time of vascular surgery were the most important risk factors for long-term adverse outcomes after revascularization. TA-related renal artery stenosis is a kind of inflammatory vasculitis, and previous studies have shown that active vascular inflammation may be associated with a higher rate of complications and restenosis after revascularization (27, 28). There are still no guidelines on how to select the best time for revascularization in TA-related stenosis. While effective preoperative medication may improve outcomes, the optimal preoperative treatment duration remains to be determined.

We found that hypertension caused by TA-related renal artery stenosis might be controlled with the combination of renal artery revascularization and medication. Three patients in our cohort stopped antihypertensive drugs after the renal artery revascularization (Supplementary Table 2); their blood pressures have been normal for 6–24 months after the procedure. Randomized controlled trials are needed to confirm the long-term effects and safety of the combination of medication and revascularization.

Our study has several strengths. First, the sample size is much larger than that of previous studies. Second, in addition to reporting the outcomes of patients with TA-related renal artery stenosis, we also identify the risk factors for adverse outcomes. The matrix model that we propose (Fig. 1A) can be conveniently applied in clinical practice to identify high-risk patients. We also analyze the outcomes and risk of adverse outcomes for the subgroup of patients undergoing revascularization procedures.

We recognize several limitations in our research. First, the follow-up duration was short. Second, there is a possibility that some patients in this study may have had fibromuscular dysplasia (FMD). FMD is a noninflammatory and nonatherosclerotic vascular disease that mainly involves the renal and carotid arteries. The typical imaging characteristic of FMD is the string-of-beads sign on DSA, CTA, or MRA. A few cases with nontypical imaging features may have been misdiagnosed.

In conclusion, our study demonstrated renal artery involvement in 30% of Chinese TA patients. Patients with uncontrolled or worsening hypertension or/and renal function may benefit from revascularization. Preoperative treatment appears to improve revascularization outcomes, though prognosis may be poorer for patients with renal insufficiency at presentation, bilateral artery involvement, and severe stenosis.

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Figure legends

Fig 1A: Matrix model for predicting risk of adverse outcomes in TA patients with renal artery stenosis. Based on baseline renal function, renal artery stenosis severity, and presence of bilateral involvement, patients could be separated into three risk groups: high risk (red, >50%), moderate risk (green, between 30%-50%), and low risk (yellow, <30%). **B:** Matrix model for predicting risk of adverse outcomes after vascular intervention. Based on renal artery stenosis severity, receipt of preoperative treatment, and disease activity at time of intervention, patients could be separated into three risk groups: high risk (red, >25%), moderate risk (green, between 10%-25%), and low risk (yellow, <10%).

Fig 2. A-B: Change in renal function (serum creatinine level and eGFR) in patients with and without preoperative treatment before vascular intervention. **C-D:** Change in blood pressure of patients with and without preoperative treatment group before vascular intervention.

Fig 3. A: Cumulative incidence of renal artery restenosis in patients with and without preoperative treatment before vascular intervention. **B:** Kaplan-Meier curves of survival without adverse outcome in patients with and without preoperative treatment before vascular intervention.

Table 1. Comparison of clinical characteristics between Takayasu arteritis patients with and without renal artery stenosis

	Total (N = 567)	With renal artery involvement (n = 172)	Without renal artery involvement (n = 395)	P-value
Demographic characteristics				
Female, n (%)	455 (80.25%)	120 (69.77%)	335 (93.31%)	0.04
Age at disease onset, year, median (IQR)	29 (22-38)	27 (16-38)	30 (22-46)	0.34
Age at diagnosis, year, median (IQR)	31 (22-38)	30 (16-39)	32 (20-47)	0.29
Clinical manifestations				
Systemic symptoms, n (%)	184 (32.45%)	35 (20.35%)	149 (37.72%)	0.03

Ischemia symptoms, n (%)	209 (36.86%)	47 (27.33%)	162 (41.01%)	0.11
Physical signs				
Pulselessness, n (%)	118 (19.76%)	29 (16.86%)	89 (22.53%)	0.47
Vascular murmur, n (%)	103 (18.17%)	25 (14.53%)	78 (19.75%)	0.51
Hypertension at presentation, n (%)	199 (35.09%)	85 (49.42%)	114 (28.86%)	0.02
Refractory hypertension, n (%)	95 (16.75%)	51 (29.65%)	44 (11.14%)	<0.01
Renal insufficiency, n (%)	67 (11.82%)	31 (18.02%)	36 (10.03%)	0.03
Treatments at presentation				
GC, mg/d, median dose (IQR)	37.5 (12.5-55)	35 (15-55)	42.5 (22.5-55)	0.71

CYC, n (%)	309 (54.40%)	87 (50.58%)	222 (61.84%)	0.53
MTX, n (%)	87 (15.34%)	26 (15.12%)	61 (16.99%)	0.77
LEF, n (%)	74 (13.05%)	25 (14.53%)	49 (13.65%)	0.51
MMF, n (%)	42 (7.41%)	9 (5.23%)	14 (3.89%)	0.04
AZA, n (%)	23 (4.06%)	14 (8.14%)	28 (7.79%)	0.48
Biological agents, n (%)	19 (3.35%)	7 (4.07%)	12 (3.34%)	0.63

IQR: interquartile range; GC: glucocorticoid; CYC: cyclophosphamide; MTX: methotrexate; LEF: leflunomide; MMF: mycophenolate mofetil; AZA: azathioprine; biological agents included tumor necrosis factor antagonist, rituximab, tocilizumab.

Table 2. Comparisons of clinical characteristics between patients with different degrees of renal artery stenosis

	<50% stenosis (n = 47)	50%-75% stenosis (n = 51)	>75% stenosis (n = 74)	P-value
Demographic characteristics				
Female, n (%)	33 (70.21%)	36 (70.59%)	51 (68.92%)	0.47
Clinical manifestations				
Systemic symptoms, n (%)	8 (17.02%)	9 (17.64%)	18 (24.32%)	0.04
Ischemia symptoms, n (%)	11 (23.40%)	10 (19.61%)	16 (21.62%)	0.31
Physical signs				

Pulselessness, n (%)	8 (17.02%)	7 (13.73%)	14 (18.92%)	0.48
Vascular murmur, n (%)	9 (19.15%)	8 (15.69%)	8 (10.81%)	0.32
Hypertension at presentation, n (%)	12 (25.53%)	21 (41.18%)	52 (70.27%)	<0.01
Refractory hypertension at presentation, n (%)	8 (17.02%)	12 (23.53%)	31 (41.89%)	0.02
Renal insufficiency at presentation, n (%)	5 (10.64%)	8 (15.69%)	21 (28.38%)	0.04
Treatments at presentation				
GC, mg/d, median dose (IQR)	25 (20-35)	30 (15-45)	40 (35-55)	0.03
Immunosuppressant, n (%)	38 (80.85%)	49 (96.08%)	74 (100%)	0.81
Biological agents, n (%)	1 (2.13%)	2 (3.92%)	4 (5.41%)	0.07

Revascularization	0	5 (9.80%)	41(55.41%)	<0.01
Adverse outcomes, n (%)	10 (21.28%)	13 (25.49%)	23 (31.08%)	0.05

IQR: interquartile range; GC: glucocorticoid; immunosuppressants included cyclophosphamide, methotrexate, leflunomide, mycophenolate mofetil, azathioprine; biological agents included tumor necrosis factor antagonist, rituximab, tocilizumab.

Table 3. Comparisons of disease features between patients with and without revascularization

	Patients with revascularization (n = 46)	Patients without revascularization (n = 126)	P-value
Clinical features			
Sex (female, %)	36 (78.23%)	84 (66.67%)	0.14
Age at diagnosis, year, median (IQR)	28 (17-36)	34 (22-37)	0.02
Delay in diagnosis >1year, n (%)	24 (52.17%)	56 (44.44%)	0.32
Hypertension, n (%)	46 (100%)	39 (30.95%)	<0.01
Refractory hypertension at presentation, n (%)	29 (63.04%)	21 (16.67%)	<0.01

Renal insufficiency at presentation, n (%)	12 (26.09%)	19 (15.08%)	0.03
Renal artery involvements, n (%)			
Bilateral involvement	17 (36.96%)	36 (30.16%)	0.32
Severity of stenosis <50%	0	33 (26.19%)	<0.01
50-75%	11 (23.91%)	59 (46.83%)	0.03
>75%	35 (76.09%)	34 (26.98%)	<0.01
Treatments for hypertension, n (%)			
CCB	37 (80.43%)	31 (79.49%)	0.44
β blocker	29 (63.04%)	30 (76.92%)	0.39

ACEI/ARB	3 (6.52%)	5 (12.82%)	0.03
Diuretic	16 (41.03%)	6 (15.38%)	0.02
≥4 drugs combination	16 (61.54%)	11 (22.92%)	<0.01

CCB: calcium channel antagonist; ACEI: angiotensin-converting enzyme inhibitor; ARB: angiotensin receptor blocker; Bilateral involvement: the number did not include those with unilateral involvement.

A

Renal artery stenosis <50%	21%	7%	Renal insufficiency at presentation
	11%	NA	No renal insufficiency at presentation
Renal artery stenosis 50-75%	74%	37%	Renal insufficiency at presentation
	49%	16%	No renal insufficiency at presentation
Renal artery stenosis >75%	92%	58%	Renal insufficiency at presentation
	79%	34%	No renal insufficiency at presentation
	Bilateral involvement	Unilateral involvement	

>50%
30%-50%
<30%

B

Renal artery stenosis <50%	NA	NA	Preoperative treatment
	NA	NA	No-preoperative treatment
Renal artery stenosis 50-75%	21%	4%	Preoperative treatment
	41%	12%	No-preoperative treatment
Renal artery stenosis >75%	31%	11%	Preoperative treatment
	57%	19%	No-preoperative treatment
	Active disease before procedure	Inactive disease before procedure	

>25%
10%-25%
<10%

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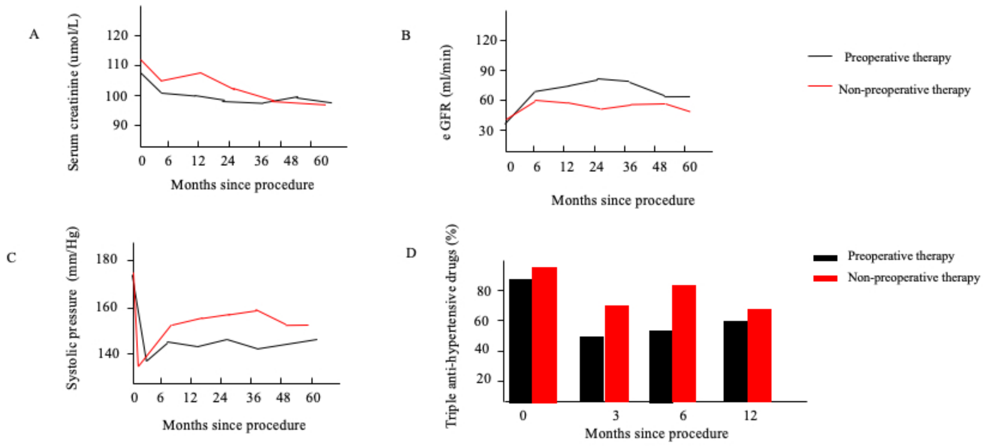

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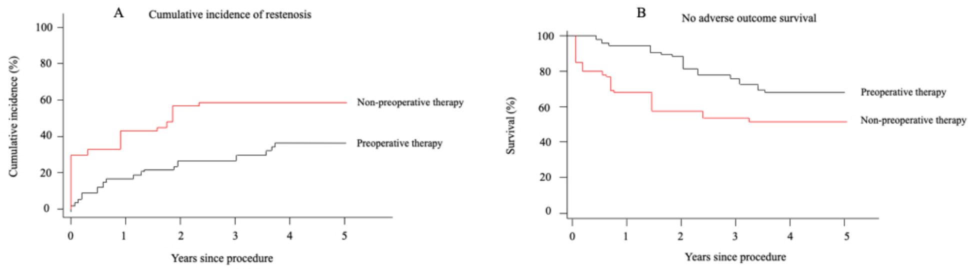

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