Retrospective Comparison of Open versus Endovascular Procedures for Takayasu Arteritis

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ABSTRACT. ***Objective.*** To compare the outcomes between vascular surgery and endovascular procedures in a cohort of patients with Takayasu arteritis (TA).

Methods. A retrospective cohort study was conducted of patients with TA who underwent vascular interventions at a tertiary center between 1984 and 2009. The American College of Rheumatology criteria for TA were used to select patients. Disease activity was assessed according to the Kerr criteria. Data are reported using descriptive statistics and Kaplan-Meier methods for complication rates.

Results. The cohort included 66 patients with TA who underwent 119 vascular procedures (surgery 93; endovascular repair 26). The most frequent indication for vascular surgery and endovascular procedure was arm claudication (surgical group 43%, endovascular repair group 31%). In 59% of the vascular surgical procedures and in 38% of endovascular procedures, the disease was active within 1 month of intervention. The most frequent arterial lesion requiring intervention was the aorta (28%) in the vascular surgery group and the subclavian (35%) in the endovascular repair group. Early complications occurred after 15 surgeries and 4 endovascular repair procedures ($p = 0.93$). Late complications occurred after 34 surgical procedures and 10 endovascular repair procedures (44% vs 66%, respectively; $p = 0.33$). The majority of complications in both groups were restenosis. Hypertension, dyslipidemia, and higher doses of corticosteroids were associated with an increased risk of postprocedural complications and restenosis.

Conclusion. In patients with TA, both open surgical and endovascular revascularization procedures are associated with high failure rates and frequent operative complications. Traditional cardiovascular risk factors, corticosteroid dose, and active disease are risk factors for restenosis after revascularization procedures. (First Release December 15 2015; J Rheumatol 2016;43:427–32; doi:10.3899/jrheum.150447)

Key Indexing Terms:
TAKAYASU ARTERITIS VASCULITIS OUTCOMES REVASCULARIZATION

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Takayasu arteritis (TA) is a form of large-vessel vasculitis of unknown etiology, affecting primarily the aorta and its branches. It occurs predominantly in women < 40 years of age. Although TA is more commonly observed in Asian women, it can occur worldwide[1].

TA often leads to significant damage of major arteries with subsequent extremity and end-organ ischemia. Management goals include alleviation of ischemic symptoms and prevention of progressive vascular damage, including the development of vascular stenosis, occlusion, or aneurysm formation. Corticosteroids are generally first-line therapy; however, relapses are common as corticosteroids are tapered[1,2]. Therefore most patients with TA receive additional immunosuppressive medications, and refractory disease is often treated with biologic agents. A significant proportion of patients with TA have progressive vascular disease despite medical therapy. Patients with symptomatic vascular damage (e.g., persistent claudication, mesenteric ischemia, transient ischemic attack) and/or end-organ dysfunction (e.g., stroke) often require revascularization procedures such as endovas-

cular repair or vascular surgery. In a US cohort of patients with TA, 55% underwent vascular interventions[3].

While initial experience with endovascular procedures was promising[4,5,6], more recent data suggest that endovascular interventions are associated with a higher failure rate compared with vascular surgery[1,2,7,8,9]. Persistent inflammation of affected vessels appears to be an important risk factor for development of complications secondary to vascular procedures[10,11,12].

We evaluated the outcomes of intervention in a large retrospective cohort of patients with TA who underwent vascular procedures at a tertiary referral center. Risk factors for complications, particularly restenosis, were assessed.

MATERIALS AND METHODS

In this retrospective cohort study, all patients were identified who were evaluated at Mayo Clinic, Rochester, Minnesota, USA, from January 1, 1984, through December 2009, with an International Classification of Diseases, 9th revision, code for TA. All medical records were reviewed to confirm the diagnosis of TA according to the 1990 American College of Rheumatology (ACR) criteria for classification of this disease[13]. Patients aged 40 to 50 years were included if they met the ACR criteria for TA without fulfilling the ACR criteria for giant cell arteritis. Patients who did not meet ACR criteria for TA were excluded.

Data abstracted from the medical records were entered into a database using the Research Data Capture (REDcap) tool hosted at the Mayo Clinic[14]. Demographic, clinical, and laboratory and radiographic data were collected. Each surgical and endovascular procedure was recorded. The indication for surgery, symptoms at the time of intervention, laboratory and imaging data, and disease activity at time of surgery were recorded, as were the type of surgery and the vascular territory requiring intervention. All early and late postinterventional complications (restenosis, thrombosis, stroke, bleeding, or other complication) were recorded. Early complications were defined as occurring within 1 month after the procedure and late complications were those occurring > 1 month after intervention. Restenosis was defined as worsening of stenosis or occlusion of a previously patent native vessel or bypass graft.

Disease activity was assessed using the US National Institutes of Health (NIH)/Kerr criteria[15]. TA was considered active if the patient had recent onset or worsening of at least 2 of these criteria: (1) systemic features, such as fever, musculoskeletal pain (no other cause identified); (2) elevated erythrocyte sedimentation (ESR) or C-reactive protein (CRP) in the absence of infection or neoplasm; (3) features of vascular ischemia or inflammation, such as claudication, diminished or absent pulse, bruit, vascular pain (carotidynia), asymmetric blood pressure in either upper or lower limbs (or both); and (4) typical angiographic features at onset of disease or worsening of the vascular lesions.

Statistical analyses. Descriptive statistics (means, percentages, etc.) were used to summarize the data. Comparisons between patients with vascular procedures and endovascular repair were performed using chi-square and Wilcoxon rank-sum tests. Procedures, rather than patients, were used as the experimental units in analyses involving the characteristics of the procedures, because the majority of subsequent procedures (83%) were in different vascular territories than the original procedure. Kaplan-Meier methods were used to estimate the complication rates.

Risk factors for postprocedural complications were examined using conditional frailty models, which are a variation of Cox models that account for multiple surgeries in the same patient by including a random effect for each patient. Only the first complication after each surgery was counted as an event (multiple complications following the same surgery were not included in the model). Statistical analyses were performed using SAS (SAS Institute) and R (R Foundation for Statistical Computing) statistical packages.

RESULTS

Study cohort. During the study period, 126 patients were diagnosed as having TA at Mayo Clinic or were evaluated at our institution within 1 year of the diagnosis. From this cohort, 66 patients underwent vascular procedures during the followup period and were incorporated in this analysis. The majority of patients were female (88%) and white (90%). At diagnosis of TA, the most prevalent cardiovascular risk factors were smoking (current smoker 23%, former smoker 25%), hypertension (HTN; 27%), and dyslipidemia (25%). The most frequent symptoms at presentation were fatigue (44%), lightheadedness (44%), upper limb claudication (43%), headache (35%), and lower limb claudication (22%). The most frequent clinical signs were vascular bruits (82%) followed by asymmetric extremity blood pressure (59%) and new-onset HTN (42%; Table 1).

Table 1. Baseline clinical characteristics of 66 patients with Takayasu arteritis who underwent interventional procedures. Data are n (%) of patients with data available, unless otherwise indicated.

Characteristic	Value
Age at diagnosis, yrs, median (interquartile range)	34.5 (24.8-40.3)
Female	58 (88)
Race	
White	46 (90)
African American	3 (6)
Other	2 (4)
Unknown	15
Hypertension	17 (27)
Smoking status	
Never	34 (52)
Former and current	31 (48)
Dyslipidemia	13 (25)
Diabetes mellitus	1 (2)
Symptoms and signs	
Fever (100.4°F)	13 (20)
Arthralgia	14 (21)
Arthritis	8 (12)
Fatigue	29 (44)
Chest pain	19 (29)
Bruits	54 (82)
Lightheadedness	29 (44)
Weight loss (> 10%)	15 (23)
Angina	6 (9)
Carotidynia	7 (11)
Amaurosis fugax	12 (18)
Visual loss	5 (8)
Stroke	3 (5)
Transient ischemic attack	7 (11)
New-onset hypertension	28 (42)
Headache	23 (35)
Unequal/absent pulses	49 (74)
Unequal blood pressure	38 (59)
Upper limb claudication	28 (43)
Lower limb claudication	14 (22)
Elevated sedimentation rate (> 29 mm/h for women, > 22 mm/h for men)	24 (47)
Elevated C-reactive protein (≥ 8 mg/l)	14 (50)

Vascular procedures. A total of 119 vascular procedures [93 (78%) surgical and 26 (22%) endovascular intervention] were performed in the 66 patients. Twenty-five patients (38%) underwent 1 vascular surgery, while 19 patients (29%) required 2 to 4 vascular surgeries. Six patients (9%) underwent 1 endovascular procedure, while 2 patients (3%) required 2 endovascular procedures. Fourteen patients (21%) underwent both endovascular and surgical procedures.

The vascular lesions requiring intervention were mainly stenosis and occlusions (n = 96, 81%) followed by aneurysm (n = 18, 15%) and pseudoaneurysm (n = 2, 2%). Three patients (3%) underwent aortic valve replacement for valvular insufficiency.

The most frequent indications for endovascular or surgical intervention were limb claudication, HTN, and heart failure (Table 2). There were no differences between the 2 intervention groups in the indication for intervention.

There were no differences in ESR (surgical group 15.5, SD = 11; endovascular group 13, SD = 8; p = 0.77) and CRP values (surgical group 9.6 mg/l, SD = 35.3; endovascular group 27.3 mg/l, SD = 60.1; p = 0.08) between the 2 intervention groups among those who were tested at the time of the procedure.

Disease activity at the time of surgery was assessed with the NIH/Kerr criteria. In the vascular surgery group, 59% of patients (n = 54) had 2 or more positive criteria and in the endovascular group, 48% (n = 10) had 2 or more positive criteria. New onset or worsening of prior angiographic lesions was the most frequent of the Kerr criteria in both groups [84% (n = 66) in the vascular surgery group; 100% (n = 18) in the endovascular group].

Corticosteroids were the most common medical treatment (46% in the vascular surgery group; 46% in the endovascular group), followed by immunosuppressant medications (28% in the vascular surgery group; 38% in the endovascular group). Six patients were using biological therapy, 3 (6%) in the vascular surgery group and 3 (12%) in the endovascular group. The use of aspirin also was similar in both groups (26% in the vascular surgery group; 31% in the endovascular group). A minority of patients were taking anticoagulants (n = 9) or statins (n = 7) before surgery (Table 3).

The distribution of arterial lesions requiring intervention is listed in Table 4. The aorta (28%; n = 26, 15 procedures in the root, ascending or arch of the aorta, 2 in the thoracic aorta, 9 in the abdominal aorta) and the carotid (23%; n = 21), subclavian (22%; n = 20), and renal (16%; n = 15) arteries were the most frequent sites of intervention in the vascular surgery group. The subclavian (35%; n = 9) and renal arteries (19%; n = 5) and the aorta (19%; n = 5, 1 procedure in the aortic arch, 2 in the thoracic aorta, and 2 in the abdominal aorta) were targeted in the endovascular repair group.

Procedure-related outcomes. The mean time from the first procedure to last followup was 6 years (SD = 7) in the vascular surgery group and 6.2 years (SD = 8.5) in the

Table 2. Indications for vascular procedures in patients with Takayasu arteritis. Data are n (%).

Indications	Surgical Procedure, n = 93	Endovascular Procedure, n = 26	p
Stroke	7 (8)	0 (0)	0.15
Transient ischemic attack	7 (8)	0 (0)	0.15
Claudication of arms	40 (43)	8 (31)	0.26
Claudication of legs	18 (19)	2 (8)	0.16
Heart failure	12 (13)	3 (12)	0.85
Mesenteric ischemia	2 (2)	1 (4)	0.63
Refractory hypertension	12 (13)	6 (23)	0.20
Kidney failure	3 (3)	1 (4)	0.88
Myocardial infarction	5 (5)	2 (8)	0.66

Table 3. Pharmacologic treatment at 1 month prior to intervention. Data are n (%).

Treatment	Surgical Procedure, n = 93	Endovascular Procedure, n = 26	p
Corticosteroids	43 (46)	12 (46)	0.99
Immunosuppressant	26 (28)	10 (38)	0.30
Methotrexate	12 (13)	8 (31)	0.031
Azathioprine	5 (5)	1 (4)	0.75
Cyclosporine	1 (1)	0 (0)	0.60
Mycophenolate mofetil	7 (8)	1 (4)	0.51
Two or more drugs	0 (0)	0 (0)	—
Biologic drugs	6 (6)	3 (12)	0.39
Infliximab	4 (4)	2 (8)	—
Adalimumab	0 (0)	1 (4)	—
Aspirin	24 (26)	8 (31)	0.61
Anticoagulant	6 (6)	3 (12)	0.39
Statins	6 (6)	1 (4)	0.62

Table 4. Arterial lesions treated by revascularization in 66 patients with Takayasu arteritis. Data are n (%).

Artery	Surgical Procedure, n = 93	Endovascular Procedure, n = 26	p
Aorta	2 (28)	5 (19)	0.37
Subclavian	20 (22)	9 (35)	0.17
Axillary	3 (3)	0 (0)	0.35
Carotid	21 (23)	1 (4)	0.030
Vertebral	3 (3)	1 (4)	0.88
Innominate	3 (3)	0 (0)	0.35
Celiac	3 (3)	0 (0)	0.35
Superior mesenteric	9 (10)	1 (4)	0.34
Inferior mesenteric	0 (0)	0 (0)	—
Renal	15 (16)	5 (19)	0.71
Iliac	3 (3)	2 (8)	0.32
Femoral	9 (10)	0 (0)	0.10
Coronary	8 (9)	3 (12)	0.65
Pulmonary	0 (0)	1 (4)	0.06

endovascular group. The frequency of early complications such as restenosis, bleeding, and stroke was low (and similar) in both groups. There were 15 (16%) early complications in the vascular surgery group and 4 (15%) in the endovascular group.

There were 34 late complications in the vascular surgery group (44% at 10-yr followup) compared with 10 late complications in the endovascular group (66% at 10-yr followup; log rank p = 0.33). Restenosis was the most common procedure-related late complication in both groups (26 after surgery and 9 after endovascular repair; 37% vs 62% restenosis rate, respectively, at 10-yr followup; p = 0.19). Other late complications in the vascular surgery group included thrombosis (4%; n = 2), stroke (2%; n = 1), and other (11%; n = 8); and the development of new pseudoaneurysm (10%; n = 1) in the endovascular repair group (Table 5).

Additional analyses were conducted to compare the rate of early and late complications in patients undergoing intervention on the subclavian vessels versus the carotid arteries, and no significant differences were detected. We also found no difference in the early and late complication rates comparing interventions for stenosis/occlusive vascular lesions and interventions for aneurysmal disease. Moreover, the complication rates in patients undergoing endovascular intervention with stenting were similar to those in whom stents were not used (data not shown).

Risk factors for complications. Using conditional frailty models, the presence of HNT (p = 0.02), corticosteroid dose (p = 0.004), and dyslipidemia (p = 0.005) were noted to be associated with postprocedural complications (Table 6).

Table 5. Complications according to type of vascular procedure performed in 66 patients with Takayasu arteritis. Data are n (%).

Variable	Surgical Procedure, n = 93	Endovascular Procedure, n = 26	p
Early complications			
Restenosis	1 (1)	1 (4)	0.33
Bleed	2 (2)	0 (0)	0.45
Stroke	3 (3)	0 (0)	0.35
Other	11 (12)	3 (12)	0.97
Any early complication	15 (16)	4 (15)	0.93
Late complications			
Restenosis*	26 (37)	9 (62)	0.19
Thrombosis*	2 (4)	0 (0)	0.54
Stroke*	1 (2)	0 (0)	0.63
Bleed*	0 (0)	0 (0)	
Other*	8 (11)	1 (10)	0.65
Any late complication*	34 (44)	10 (66)	0.33
Any complication*	35 (45)	10 (66)	0.44
Deaths associated with the procedure	3 (3)	1 (4)	0.85

* Percentages are Kaplan-Meier event rates at 10 years after surgery; p values are log-rank tests among 97 procedures (78 surgical procedures, 19 endovascular procedures) with at least 30 days of followup.

Table 6. Risk factors for postprocedural complications and restenosis.

Variable	Any Postprocedural Complication, HR (95% CI)	Restenosis, HR (95% CI)
Endovascular repair	1.15 (0.59–2.25)	1.33 (0.58–3.06)
Age at surgery	0.87* (0.67–1.13)	0.70* (0.48–1.01)
Sex male	0.41 (0.12–1.39)	0.43 (0.09–2.07)
Corticosteroid use	1.45 (0.83–2.52)	2.08 (0.96–4.51)
Corticosteroid dose**	**1.15 (1.04–1.26)**	**1.23 (1.05–1.45)**
Immunosuppressant use	1.08 (0.59–1.97)	1.32 (0.59–2.92)
Aorta	1.10 (0.59–2.07)	**0.33 (0.11–0.99)**
Thoracic	1.35 (0.77–2.36)	1.82 (0.86–3.85)
Abdominal	1.33 (0.72–2.45)	0.95 (0.41–2.23)
Emergency procedure	2.53 (0.99–6.48)	1.41 (0.29–6.81)
Arm claudication	0.83 (0.47–1.47)	1.14 (0.54–2.41)
Leg claudication	0.93 (0.43–1.98)	0.85 (0.29–2.44)
Heart failure	0.73 (0.28–1.90)	0.22 (0.03–1.67)
Myocardial infarction	1.34 (0.49–3.66)	2.49 (0.77–8.12)
Hypertension	**2.40 (1.12–5.16)**	**4.91 (1.42–17.00)**
Dyslipidemia	**2.93 (1.38–6.25)**	**4.25 (1.41–12.79)**
Diabetes mellitus	0.79 (0.09–6.91)	—
Current smoker (vs never)	0.41 (0.18–0.94)	0.37 (0.11–1.24)
Former smoker (vs never)	0.78 (0.41–1.49)	0.93 (0.37–2.32)
NIH criterion 1 (systemic features, fever, musculoskeletal pain)	0.72 (0.22–2.35)	0.89 (0.19–4.09)
NIH criterion 2 (elevated ESR)	2.59 (0.94–7.09)	1.92 (0.33–11.9)
NIH criterion 3 (features of vascular ischemia or inflammation)	1.99 (0.95–4.18)	**3.14 (1.06–9.27)**
NIH criterion 4 (typical angiographic features)	1.8 (0.63–5.16)	1.89 (0.43–8.32)
NIH criteria (2+ vs 0–1)	1.45 (0.80–2.63)	1.75 (0.77–3.99)

* HR reported per 10-year increase (values in bold type are statistically significant). ** Per 10 mg/day increase. NIH: US National Institutes of Health; ESR: erythrocyte sedimentation rate.

Current smoking was found not to be a risk factor after adjustment for age and sex (p = 0.11). Emergency surgery was associated with a higher risk for postprocedural complications (p = 0.05), as were NIH/Kerr criterion no. 2 (elevated ESR or CRP; p = 0.06) and the NIH/Kerr criterion no. 3 (features of vascular ischemia or inflammation; p = 0.07), but these associations did not achieve statistical significance. Using the same statistical analysis, HTN (p = 0.01), dyslipidemia (p = 0.01), corticosteroid dose (p = 0.012), and symptoms of vascular ischemia (Kerr criterion no. 3; p = 0.04) were associated with an increased risk of restenosis. Procedures of the aorta (p = 0.05) were associated with a lower risk of restenosis. The age at surgery (p = 0.06) was marginally associated with a decreased risk for restenosis.

DISCUSSION

We evaluated a cohort of patients with TA who underwent vascular procedures at a single tertiary referral center. As in other studies, revascularization procedures were associated with high failure rates and frequent operative complications. We observed a trend toward a higher rate of restenosis in

patients who underwent endovascular procedures compared to vascular surgery. The presence of comorbidities (HTN and dyslipidemia) and higher doses of corticosteroids were associated with an increased risk of postprocedural complications, including restenosis.

Patients with TA frequently require vascular procedures with revascularization, with rates of surgical interventions varying between 12% and 70% depending on the center[12]. Endovascular procedures such as dilatation of vascular stenosis and stent placement have emerged as a good alternative to open surgical procedures, especially in patients with high surgical risk. Initial results with endovascular procedures were promising, published mainly as case reports and small case series[4,5]. However, more recent series have reported a higher rate of complications in patients who underwent endovascular procedures[1,9,16]. Endovascular repair has been associated with a higher rate of restenosis and revision surgery. In the study by Saadoun, *et al*, 37.5% of 104 surgical procedures were followed by complications, compared to 50% of the 62 endovascular repairs[2]. Lee, *et al*[8] reported the outcomes of 65 patients with TA who underwent 111 vascular procedures. By 2-year followup, recurrence of symptoms was higher in the patients with endovascular repair compared to the surgical group (32.3% vs 11.5%, respectively; p = 0.02). In our study, while it was not statistically significant, the number of late complications was higher in the group undergoing endovascular procedures compared with open surgery. It has been hypothesized that the increased risk of restenosis from endovascular intervention may be secondary to the location and characteristics of the vascular lesions observed in TA. For example, long-segment disease or irregular or fibrosed vascular lesions may be less amenable to endovascular repair. This experience suggests that the use of endovascular procedures should be limited to a specific subset of patients (for example, those with high surgical risk) or for a specific type of lesion[15], such as short focal stenosis without evidence of active disease[16,17]. Comparing intervention on the subclavian vessels with carotid procedures, we found no significant differences in outcomes, although the number of endovascular interventions was small. Subclavian lesions in particular may be associated with worse outcomes. In our series, 5 of the 9 endovascular procedures that led to restenosis were subclavian lesions; however, the data should be interpreted with caution owing to the small sample size. Detailed information regarding the characteristics of vascular lesions that underwent intervention was not available in this retrospective study. Thus we were unable to evaluate lesion characteristics as a predictor of outcome.

TA disease activity at the time of vascular intervention is likely to be an important factor in determining surgical outcomes. In the study by Fields, *et al*[10], patients with active disease had a higher risk of a new surgical revision compared to patients with quiescent disease. Saadoun, *et al*[2] reported that active inflammation at the time of revascularization was independently associated with the occurrence of arterial complications. Specifically, patients who experienced complications after vascular procedures had higher levels of ESR, CRP, and fibrinogen. In our study, incomplete laboratory data (ESR and CRP) at the time of intervention prevented us performing an analysis between acute-phase reactants and the risk of complications and restenosis. However, we used the NIH/Kerr[15] criteria to evaluate the activity of TA before the vascular procedure. We found a relationship between only 1 of the 4 criteria (features of vascular ischemia or inflammation) and an increased risk of complications. In our cohort, a significant number of procedures were performed during active disease, which likely contributed to the high rate of complications. The proportion of patients with active disease may even have been underestimated in our study because of the lack of sensitive radiographic imaging studies in the past.

Outcomes for both open surgical and endovascular procedures are generally more favorable in patients with inactive disease (taking or not taking treatment) at the time of intervention[10]. The NIH/Kerr criteria categorize patients' disease as active in the presence of certain clinical and laboratory data. Limitations of using these criteria include the lack of validation and the challenge of applying them in a retrospective medical record review[18]. Current work to generate better scoring procedures to help the clinician evaluate disease activity and to guide changes in therapy should aid in understanding the contribution of disease activity to interventional outcomes[18,19,20,21]. As well, advanced imaging methods including positron emission tomography-computed tomography may prove useful in the assessment of disease activity[22,23].

The relationship between the dose of corticosteroid and increased risk of postprocedural complications and restenosis may reflect that patients had active disease at the time of intervention. This observation confirms that vascular procedures should be performed when the disease is in remission, and when patients are undergoing adequate immunosuppressive therapy. Most patients with TA require a combination of corticosteroids and an immunosuppressive agent to achieve remission, and those with refractory disease are generally treated with a tumor necrosis factor inhibitor.

The risk of restenosis was lower in patients undergoing procedures of the aorta in our study. This coincides with findings by Lee, *et al*[8], who reported a patency rate of 100% following percutaneous transluminal angioplasty and bypass surgery procedures in the aorta. This may be related to the large luminal diameter of the aorta or other as yet unknown factors.

The strengths of our study include the large patient cohort and length of followup. Our findings contribute to knowledge about management of this rare type of vasculitis, providing a detailed descriptive analysis of clinical factors, treatments, symptoms, and early and late complications of TA. Together

with recent reports[1,2,8], our findings could help guide the clinician in decision making when a vascular procedure is being considered.

Our analysis is subject to the inherent limitations of a retrospective cohort study. Missing data that were not available in medical records may have affected our results. In particular instances, if documentation was incomplete, we may have misclassified the disease activity at the time of vascular intervention. As well, all patients were seen at Mayo Clinic, a tertiary referral center. For this reason, it is possible that a referral bias affected our data. However, TA is a rare disease and it is likely that most cases are evaluated in a tertiary referral setting. In addition, the small number of endovascular repairs in comparison to the larger number of surgical procedures can make it difficult to interpret the findings. However, the statistical analyses correctly accounted for the sample size of each group. Finally, the findings may be limited primarily to the US white population, reflecting the demographic composition of our patients.

Patients with TA frequently undergo revascularization procedures. Endovascular procedures are an alternative to open surgery for treatment of vascular complications in TA. Both types of interventions are associated with a significant risk of complications. Traditional cardiovascular risk factors, corticosteroid dose, and active disease are risk factors for restenosis after revascularization procedures. However, revascularization procedures are an important aspect of the management of patients with TA, and outcomes are favorable when the intervention is performed at a time the vasculitis is in remission.

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