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ORIGINAL ARTICLE

Vertebral Artery Dissections: A Retrospective Data Analysis of a Single Center

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Abstract

Objective: The aim of our study is to reveal the etiological, anatomical, and morphological characteristics and treatment results of vertebral artery dissections.

Methods: A total of 97 patients, who underwent at least 1 digital subtraction angiography examination and had proven to have vertebral artery dissection in the interventional neuroradiology department between 1994 and 2019, were included in this study. Statistical analyses were performed to evaluate the age, gender, onset of symptom presentation, history of any trauma in the head and neck region, medical history of known diseases or additional vascular pathologies, follow-up duration, and morphological characteristics of the dissected vertebral arteries.

Results: Of 97 patients, 53 (54.6%) were male and 44 (45.4%) were female. The mean patient age was 44.5 ± 14.2 years (range: 3-75). Thirty-seven (38.1%) patients had chronic and 60 (61.9%) patients had acute vertebral artery dissection. While dissection was detected in the bilateral vertebral artery in 13 (13.4%) patients, involvement of multiple segments was noted in 12 (12.4%) patients. The rate of fusiform/aneurysmal dilatation was significantly increased in vertebral artery dissection on the dominant or codominant side, and a greater rate of luminal irregularity/steno-occlusion was evident on the dissection of nondominant vertebral artery ($P < .001$).

Conclusion: Patients with vertebral artery dissection may present with a wide spectrum of signs, ranging from asymptomatic to severe strokes of vertebrobasilar system or subarachnoid hemorrhage. As a result of advances in imaging modalities, endovascular techniques, and materials, especially in the last 2 decades, significant progress has been made in the treatment of vertebral artery dissections and related pseudoaneurysms.

Keywords: Vertebral artery dissection, digital subtraction angiography, vascular system injuries/therapy

Introduction

Dissection refers to the penetration of blood between the layers of the arterial wall as a result of a tear. The exact location of the intramural hematoma between the layers of arterial wall is substantial because it frequently results in luminal stenosis when located between the intima-media and aneurysmal dilatation of the artery when predominantly involves the media and adventitia.[1] Although the estimated incidence of vertebral artery dissection is 2.6/100 000, it is among the most common causes of stroke in people between the ages of 18-45.[2] Although various factors predisposing to the formation of vertebral artery dissection have been identified in the literature, the most important among these are trauma and genetic disorders that cause vasculopathy or connective tissue disorders.[2,3]

The vertebral arteries originate from the ipsilateral subclavian arteries and are divided into 4 anatomical segments. Dissections can occur in any segment of the vertebral artery, and there is no consensus among the authors in the literature regarding the susceptibility of these 4 vertebral artery segments to dissections.[4]

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Patients with vertebral artery dissection may present with a wide spectrum of signs, ranging from asymptomatic to severe strokes of vertebrobasillary system or subarachnoid hemorrhage. Since ischemic strokes secondary to vertebral artery dissection may be at the level of the medulla, pons, cerebellum, occipitotemporal region, or spinal cord, clinical presentation varies according to the involved territory. Therefore, the suspicion of physicians regarding vertebral artery dissection constitutes one of the most important steps in diagnosis.

The clinical consequences of vertebral artery dissections mainly depend on the exact localization of the dissection, the degree of luminal stenosis and thromboemboli caused by the dissection, the status of collateral circulation, the presence of pseudoaneurysm, and subarachnoid hemorrhage.

Doppler ultrasound, magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), computerized tomography (CTA), and digital subtraction angiography (DSA) can be used to visualize vertebral artery dissection. Doppler ultrasound can demonstrate blood flow disturbances with narrow, bi-directional complexes due to increased resistance to the blood flow in the cervical and cerebral arteries and also the intimal arterial flap in the lumen. However, when the intimal flap could not be demonstrated, it may be insufficient to delineate the exact localization and etiology (atherosclerosis or dissection) of the stenosis. Arterial wall hematoma and ischemic foci can be displayed successfully with fat-saturated T1-weighted axial MRI and DWI, respectively. Magnetic resonance angiography and computerized tomography can demonstrate irregularities in the arterial wall, stenosis, occlusion, or pseudoaneurysms. Digital subtraction angiography (DSA) is the gold standard imaging method in the evaluation of vertebral artery dissection and related vascular wall irregularities, luminal changes, and aneurysmal dilatation, and it is of great importance for allowing therapeutic interventions. Accurate diagnosis plays a substantial role in the early treatment and prevention of complications that may develop.

The aim of our study is to reveal the etiological and anatomical characteristics of vertebral artery dissections and the treatment results of patients with vertebral artery dissections in our clinic for the last 25 years.

Method

Patients

This retrospective study was approved by İstanbul University-Cerrahpaşa Ethics Committee (Date: June 2, 2022, No: 2022/395636) and carried out according to the requirements of the Declaration of Helsinki. Informed consent was waived off due to the retrospective design of the study.

A total of 97 patients, who underwent at least 1 DSA examination and had proven to have vertebral artery dissection in the interventional neuroradiology department between 1994 and 2019, were included in this study. Patients without a DSA examination and a control MRA or DSA examination were excluded from the study, considering that it would be inadequate to show accurate treatment results.

Imaging Analysis

Digital subtraction angiography examinations were performed on a C-arm mount monoplane Philips V3000 Integris digital angiography unit (Philips Medical Systems, The Netherlands) between 1994 and 2010 and Philips Integris Allura and Allura Xper FD 20/20 biplane angiography (Philips Medical Systems) after 2010.

We retrospectively reviewed the medical records and DSA images of the patients in the study group. For each patient, age, gender, onset, presenting symptom, history of any trauma in the head and neck region, medical history of known diseases, and follow-up duration were collected from the records of the hospital database.

The morphological characteristics recorded from the DSA images were the dominant side of the vertebral artery (right, left, codominance), dissection side of the vertebral artery (right, left, bilateral), the segment of dissection (V1, V2, V3, V4, multiple segments), arterial wall irregularities, luminal stenosis, aneurysmal dilatation/pseudoaneurysm, and morphological abnormalities in DSA apart from vertebral artery dissection.

The morphology of vertebral artery dissection in DSA examination was divided into 3 main types: luminal irregularity, steno-occlusive changes, and aneurysmal dilatation.

Treatment Strategy

The patients were also categorized into 2 groups according to the treatment strategy: medical conservative treatment and interventional endovascular procedure. A medical conservative approach has been preferred in the treatment of luminal wall irregularity and steno-occlusive changes secondary to dissection. Anticoagulant/antiplatelet therapies (low-molecular-weight heparin, aspirin, and clopidogrel) have formed the basis of medical conservative treatment.

Interventional endovascular treatments have been preferred in cases where the patient/or their caregivers provided written informed consent to endovascular treatment, with fusiform/arterial dilatation secondary to dissection with a diameter ratio between the dissecting and normal segment of vertebral artery of ≥1.5 and/or progression of fusiform/arterial dilatation on follow-up images.[5] The endovascular approach included parent artery occlusion with coil or double balloon technique or as in recent years, placement of flow-diverter stents that provide reconstruction of the vessel wall.

Follow-Up

In cases with short-segment vessel wall irregularities only and/or stenosis less than 50% in the DSA examination, the control evaluation was performed with MR angiography in the third month. Sixth month control DSA examination was performed in patients who were detected with more than 50% stenosis, multisegment vessel wall irregularities, and arterial dilatation /pseudo aneurysm formation in prior DSA examination.

During the follow-up period, changes in the morphology of the vertebral artery dissection demonstrated 4 main patterns in the affected vessel: no interval change, progression of stenosis or aneurysmal dilation of the artery, regression in the degree of stenosis or in the size of aneurysmal dilatation, and resolution with normalization. Vascular normalization following vertebral artery dissection was defined by the absence of a diametric difference between the dissecting and normal segments of the dissecting vertebral artery or resolution of wall irregularities in cases in which a diametric difference had been present.[5]

Statistical Analysis

Statistical analyses were performed using International Business Machines Statistical Package for the Social Sciences Statistics, version 23 (IBM SPSS Corp., Armonk, NY, USA). After the research data were digitized, frequency and percentage values were calculated for categorical variables, and mean and standard deviation values were calculated for continuous variables. The statistical significance of the morphological characteristics according to the side of dissection was assessed by means of a chi-square test. The significance level for analysis was set as $P < .05$.

Results

Of the 97 patients included in the study, 8 were in the pediatric age group [10.8 ± 4.1 (range: 3-16)] and 89 were adults [44.2 ± 11.1 (range: 21- 75)] and the mean age was 44.5 ± 14.2 years (range: 3-75); 53 patients (54.6%) were male, whereas 44 (45.4%) of them were female in the study group.

According to the type of onset, 37 (38.1%) patients had chronic dissection and 60 (61.9%) patients had acute vertebral artery dissection. Eight (8.2%) of the patients were asymptomatic in terms of vertebral artery dissection detected in examinations performed for other reasons. Of the remaining patients, 65 (67%) patients were investigated for symptoms secondary to ischemic stroke, 14 (14.4%) patients for subarachnoid hemorrhage, and 10 (10.3%) patients for neck pain.

There was a close distribution of dissection segments in the vertebral artery in the whole study group. V1, V2, V3, and V4 segments were involved in dissection for 26, 32, 32, and 37 cases, respectively. While dissection was observed in the bilateral vertebral artery in 13 (13.4%) patients, involvement in multiple segments was noted in 12 (12.4%) patients. Intracranial and extracranial vertebral artery dissections did not show a statistically significant

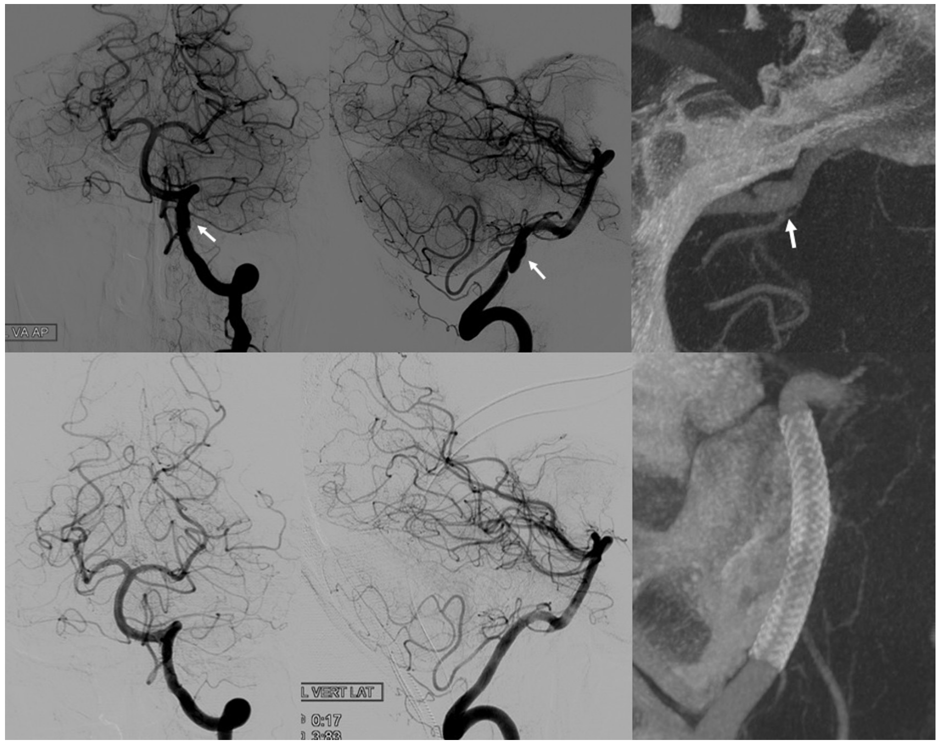

Figure 1. Images from a 55-year-old man with a VA dissecting aneurysm. AP and lateral left vertebral angiogram shows the dissecting aneurysm (arrows) in the intracranial segment of the left VA. Flat panel detector CT angiography image of the dissected segment of left VA and associated pseudoaneurysm. The left PICA (arrow) arises from the posterior wall of the dissected segment of VA. AP and lateral left vertebral angiogram demonstrates the reconstruction of the left VA following the endovascular treatment with a flow diverter stent. DSA, digital subtraction angiography; CT, computed tomography; VA, vertebral artery; AP, anterior-posterior; PICA, posterior inferior cerebellar artery.

difference in distribution between genders (P = .494). Of the 13 cases with bilateral vertebral artery dissection, 10 (76.9%) were males and 3 (23.1%) were females. Of the vertebral artery dissections, 57.3% were observed in the dominant or codominant vertebral arteries (Figure 1).

When vertebral artery dissections were evaluated according to their etiology, dissection was detected due to major trauma in 11 patients, while iatrogenic dissection occurred during DSA examination or endovascular treatment in 7 patients. Vertebral artery dissection was considered spontaneous in the remaining 79 cases. While vertebral artery dissections due to major trauma were most commonly detected in V1 (n = 4, 36.4%), V2 (n = 4, 36.4%), and V3 (n = 3, 27.2%) segments, only V1 (n = 4, 57.1%) and V2 (n = 3, 42.9%) segments were involved in iatrogenic cases.

In 8 pediatric patients (6 males and 2 females), the V3 segment was the most commonly involved segment, while no dissection was observed in the V1 segment. V4 segment stood out as the most frequently affected segment by dissection following the vertebral artery V3 segment. Bilateral vertebral artery dissection was detected in one of these pediatric patients, and 1 patient was found to have multisegment involvement.

Among the morphological changes detected in the DSA examination, pseudoaneurysm dilatation and luminal irregularity were the leading ones (Figure 2). The most common vertebral artery dissections resulting in aneurysmal dilatation/pseudoaneurysm were located in V4 segment (n = 22, 62.9 %) and it was followed by V3 segment dissections (n = 7, 20%). The morphology of the vertebral artery dissections in the dominant or codominant VA was fusiform/aneurysmal dilatation in 28 patients (80%) and luminal irregularity/steno-occlusion in 31 patients (41.3%). In contrast, the morphology of the vertebral artery dissections in the nondominant vertebral artery was fusiform/aneurysmal dilatation in 7 patients (20%) and luminal irregularity/steno-occlusion in 44 patients (58.7%). The rate of fusiform/aneurysmal dilatation was significantly higher in vertebral artery dissection on the dominant or codominant side, and a higher rate of luminal irregularity/steno-occlusion was evident on the dissection of nondominant vertebral artery ($P < .001$).

Totally, 76 patients with vertebral artery dissection were treated with a medical conservative approach using anticoagulants for 3-6 months, and a dual antiplatelet regimen was started in 42 patients due to the persistence of luminal irregularity or stenosis in the MRA or DSA performed at the end of the sixth month. In total, 21 of 97 patients were treated with an endovascular approach. Of these, 15 patients were treated with parent artery occlusion and all cases with acute subarachnoid hemorrhage with underlying pseudoaneurysms secondary to V4 segment dissection (n = 14) were treated in the first 2 weeks following the hemorrhage. Flow diverter stents were used in the treatment of 6 symptomatic pseudoaneurysms, and there were no technical difficulties or complications in these procedures. The median follow-up duration of the patients in the study group was 22 months (range: 2 months-79 months). Morphological characteristics, treatment strategy, and follow-up morphology are presented in Table 1.

Of the 110 vertebral artery dissections in 97 patients, vascular normalization of the vertebral artery was observed in 39 vertebral arteries during the follow-up period. The mean age of the patients with vascular normalization in the control examinations was 41.2 ± 13.9 (range: 16-75) years, and there was no statistically significant difference in gender distribution among these patients.

Figure 2. AP left vertebral arteriogram shows long segmental luminal irregularities (arrow) involving the V1 and V2 segment of the left VA. The patient was treated with conservative medical approach. DSA and flat panel detector CT angiography images demonstrated the near-total regression of the luminal irregularities associated with dissection. CT, computed tomography.

While no interval change was observed between the control examination and the first DSA examination in 29 vertebral arteries, partial regression was noted regarding the wall irregularities or stenotic changes in 17 vertebral arteries. In total, 10 dissections showed progression in the control examination, and the mean age of the patients, whose lesions showed progression, was found to be 58.4 years ± 13.6 (range: 45-71). Morphological changes following treatment of the patients with vertebral artery dissections are presented in Table 2.

When the DSA findings detected other than vertebral artery dissection were examined, 53 (54.6%) of the patients with vertebral artery dissection had other vascular variations, vascular pathologies, or known vascular diseases on DSA examination. Vertebral artery dissection was the only pathological finding in the remaining 32 (32.9%) patients. Widespread atherosclerotic changes and related steno-occlusive changes in ICA were observed in 13 (13.4%) patients. Intracranial aneurysms apart from the vertebral artery were detected in 11 (11.3%) patients, whereas 7 (7.2%) patients had ICA dissection accompanying vertebral artery dissection. Associated vascular variations and other abnormalities are summarized in Table 3.

Discussion

In this study, we aimed to evaluate the etiological, anatomical, and demographic features and outcomes of vertebral artery dissections. Although spontaneous vertebral artery dissection can affect all age groups, it has been reported to peak in the fifth decade of life and predominantly affect males.[6-8] The present study has similar results that confirm the reports in the literature. In a study conducted by Hasan et al.[9] it was reported that vertebral artery dissection affects boys 6.6 times more frequently than girls in the pediatric age group. In our study, 6 (75%) out of 8 patients in the pediatric age group were male. Thanvi et al[1] stated that men are more frequently affected by intracranial vertebral artery dissections; however, in our series, intracranial vertebral artery dissections did not show a statistically significant difference in distribution between the genders. Additionally, although female predominance has been reported in the literature regarding bilateral vertebral artery dissections, more than 3/4 of the cases with bilateral vertebral artery dissections in our series were male.

Vertebral artery dissections are more common in dominant or codominant arteries. In a study conducted by Kim et al.[5] detected vertebral artery dissections were shown to occur in dominant or codominant vertebral arteries at a rate of 56%. Vertebral artery dissections were detected in dominant or codominant vertebral arteries in 53.6% of cases in our study. According to Kim et al.[5] steno-occlusive changes were more frequently observed in non-dominant artery dissections, while pseudoaneurysm/aneurysmal dilatations were more common in dominant or codominant vertebral artery dissections. These findings were also confirmed in our series.

The majority of dissection-related infarctions were reported to be thromboembolic rather than hemodynamic in origin, and transcranial Doppler studies have demonstrated a high intracranial microembolism tendency.[10] Therefore, anticoagulation with intravenous heparin followed by oral warfarin has substantial importance in patients with acute vertebral artery dissection unless there are contraindications such as large infarction showing mass effect, hemorrhagic transformation of infarction, intracranial extension of the dissection, and the presence of accompanying intracranial aneurysm.[11-13] The international normalized ratio is targeted to be between 2.0 and 3.0, and anticoagulants are often used for 3-6 months.[3] If the luminal irregularities and stenosis persist after 6 months, discontinuation of anticoagulant therapy and use of antiplatelets may be beneficial.[3] In a recent randomized study performed in order to determine whether antiplatelet or anticoagulant therapy is more effective in preventing stroke in cervical dissection and the risk of recurrent stroke, the analysis of outcomes by treatment arm showed no difference between antiplatelet and anticoagulant therapy.[14] In the same study, it was revealed that there was also no difference in the proportion of patients with residual occlusion and/or stenosis or with residual dissecting aneurysm between those treated with antiplatelet and anticoagulant therapies.[14]

Vertebral artery dissections can progress despite medical treatment. It has been shown that the vascular healing event can be affected by several factors, and it was stated that vascular healing following dissection was positively associated with female sex and negatively associated with smoking.[5] In our study, 10 vertebral dissections showed radiological progression in the control examination, and the mean age of the patients, whose lesions showed

Table 1. Morphological Characteristics, Treatment Strategy, and Follow-Up Data in the Patients with Vertebral Artery Dissection

	No	%
Dominant side of vertebral artery		
Right	34	35.1
Left	37	38.1
Codominance	26	26.8
Side of vertebral artery dissection		
Right	45	46.1
Left	39	40.2
Bilateral	13	13.4
Segment of dissection*		
V1	26	
V2	32	
V3	32	
V4	37	
Multiple segments	12	
Etiology of vertebral artery dissection		
Trauma	11	11.3
Iatrogenic	7	7.3
Spontaneous	79	81.4
Morphological changes in DSA*		
Luminal irregularity	45/110	40.9
Stenosis	17/110	15.5
<50%	10/110	9.1
50%-99%	7/110	6.4
Occlusion	13/110	11.8
Pseudoaneurysmal dilatation	35/110	31.8
Treatment strategy		
Conservative medical treatment	76	78.3
Parent artery occlusion	15	15.5
Double balloon	3	3.1
Coils	12	12.4
Flow-diverter stent	6	6.2
Follow-up morphology in DSA*		
No change	29/110	26.3
Partial regression	10/110	9.1
Progression	17/110	15.5
Vascular normalization	39/110	35.5
Parent artery occlusion	15/110	13.6

*These categories were evaluated according to the total number of dissections.
DSA, digital subtraction angiography.

Table 2. Morphological Changes Following the Treatment of the Patients with Vertebral Artery Dissections

	Luminal Irregularity	Stenosis or Occlusion	Aneurysmal Dilatation	Total
Changes in morphology	45	30	35	110
No change	6	16	7	29
Progression	4	2	4	10
Partial regression	7	7	3	17
Vascular normalization	28	5	6	39
Parent artery occlusion	-	-	15	15

progression, was found to be 58.4 years ± 8.6 (range: 45-71). Although recanalization following occlusion has been reported in the literature,[14,15] no cases with recanalization were observed in occluded vertebral arteries secondary to dissection in our study group. This may be due to the fact that almost all of the cases presenting with vertebral artery occlusion were referred to our clinic during the chronic period.

Since acute ruptured dissections are unstable lesions, the tendency for re-bleeding is high. It has been reported in the literature that in untreated patients, the rate of re-bleeding reaches approximately 70%, and the mortality rate of cases with re-bleeding exceeds 45%.[16,17] As these data revealed, 14 pseudoaneurysm cases, who presented with acute subarachnoid hemorrhage, were

Table 3. Associated Vascular Variations and Other Abnormalities in DSA and Known Vascular Pathologies in Patients with Vertebral Artery Dissection

	Number of Patients	%
Atherosclerosis and steno-occlusive disease of cerebral vasculature	16	16.5
Aberrant right vertebral artery	3	3.1
Aortic origin of left vertebral artery	7	7.2
Intracranial aneurysm	14	14.4
Arteriovenous malformation	2	2.1
Arteriovenous fistula	2	2.1
ICA dissection	7	7.2
Cerebral vasoconstriction syndrome	1	1.0
Fibromuscular dysplasia	6	6.2
Systemic vasculitis or PACNS	3	3.1
Fenestration in cerebral vasculature	3	3.1
Glomus caroticum	2	2.1
Fractures of head and neck region	5	5.2

DSA, digital subtraction angiography; ICA, internal carotid artery; PACNS, primary angiitis of the central nervous system.

treated with an endovascular approach as early as possible in order to prevent mortality and morbidity in our study group.

Aneurysmal dilatation that becomes symptomatic or enlarged on control examinations requires interventional treatment.[3] In addition, if treatment with anticoagulation fails or high-grade stenosis in chronic VADs persists, treatment with an endovascular approach may be required to prevent ischemic or thromboembolic complications.[3] Stent implantation has the advantage of remodeling the blood flow and preserving the patency of the parent artery with the reconstruction of the vessel wall. However, technical difficulties and complications may arise when navigating the stent, microcatheter, or micro guidewire through the dissected segment. In our series, vascular normalization of aneurysmal dilatation was achieved following the placement of flow diverter stents in 6 patients, and no technical difficulties or complications were observed in these procedures.

The present study has several limitations. The main limitation is the retrospective nature of the study. Secondly, the study includes a limited number of patients from a single institution. The third limitation is that our clinic is a referral center in a tertiary hospital; therefore, the number of patients with intracranial vertebral artery dissection (V4 segment dissection) and a tendency for complications such as pseudoaneurysms following vertebral artery dissection are high.

Vertebral artery dissection is an important vascular pathology that causes serious complications such as steno-occlusive vascular disorders, pseudoaneurysm, subarachnoid hemorrhage, or stroke and should be kept in mind in the differential diagnosis, especially in young stroke patients. Recognition of morphological findings in vertebral artery dissection will be helpful in predicting possible complications. Early diagnosis and treatment of vertebral artery dissection are of great importance in preventing mortality and morbidity. As a result of advances in imaging modalities, endovascular techniques, and materials, especially in the last 2 decades, significant progress has been made in the treatment of vertebral artery dissections and related steno-occlusive disease or pseudoaneurysms.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of İstanbul University-Cerrahpaşa Ethics Committee (Date: June 2, 2022, No: 2022/395636).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

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Declaration of Interests: The authors have no conflicts of interest to declare.

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