



Endovascular Treatment of Internal Carotid Artery Aneurysms

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ABSTRACT

Objective: Internal carotid artery (ICA) aneurysms constitute an important subset of cerebral aneurysms. Endovascular treatment interventions are progressively increasing with the advancements in technology. In many developed countries, it is increasingly becoming the preferred minimally invasive approach for the treatment of cerebral aneurysms. In this study, our aim was to examine the efficacy of endovascular interventions in treating ICA aneurysms, utilizing the experience gained from patients with ICA aneurysms who underwent endovascular intervention in our clinic.

Material and Methods: The study included 98 patients with ICA aneurysms who were admitted to our clinic between 2016 and 2022 and underwent treatment using the endovascular method. The occlusion rates of aneurysms were evaluated using the Raymond-Roy occlusion classification (RROC), while the scores of the patients on discharge were assessed using the modified Rankin Scale (mRS).

Results: Of the study patients, 57 were female, and 68 patients presented with subarachnoid hemorrhage. In 21 patients, only a flow-diverting stent was implanted, while 77 patients underwent coiling together with flow-diverting stent implantation. The modified Rankin Score on discharge was 0 in 73 patients, 1 in six patients, 3 in nine patients, and 4 in four patients. Six patients died. Of the remaining 92 patients, complete occlusion was observed at the six-month follow-up visit in 86 patients and six patients underwent flow-diverting stent placement with a second intervention.

Conclusion: At the end of our study, 81% of the patients were discharged with good results and the mortality rate was 6%. Complete occlusion was achieved in 87% of the patients. Endovascular treatment of ICA aneurysms is effective and safe. It can be considered as an alternative to surgical treatment in eligible patients.

Keywords: Internal carotid artery aneurysm, flow diverter stent, coil, endovascular treatment

ÖZ

İnternal Karotid Arter Anevrizmalarında Endovasküler Tedavi

Giriş: İnternal karotid arter (ICA) anevrizmaları intrakraniyal anevrizmalar arasında önemli bir yer oluşturur. Endovasküler tedavi girişimleri ilerleyen teknolojik gelişmelerle birlikte her gün daha da artmaktadır. Pek çok gelişmiş ülkede serebral anevrizma tedavisinde minimal invaziv yaklaşım olması nedeniyle daha çok tercih edilmektedir. Bu çalışmamızda, endovasküler girişimle kliniğimizde tedavi edilen ICA anevrizma hastalarından edindiğimiz tecrübelerle birlikte endovasküler girişimlerin ICA anevrizma tedavisindeki etkinliğini irdelemek istedik.

Gereç ve Yöntemler: Çalışmaya kliniğimize 2016-2022 yıllarında başvuran, ICA anevrizması olup endovasküler yöntemle tedavi edilen 98 hasta alındı. Anevrizmaların oklüzyon oranlarını değerlendirmede Raymond-Roy klasifikasyonu ve hastaların çıkış skorlarını değerlendirmede modifiye Rankin Skalması kullanıldı.

Bulgular: Hastaların 57'si kadındı ve 68'i subaraknoid kanama ile başvurdu. Yirmi bir hastaya sadece akım yönlendirici stent yerleştirilirken 77 hastaya akım yönlendirici stentle birlikte coil ile embolizasyon yapıldı. Yetmiş üç hasta modifiye Rankin Skoru 0, altı hasta Modifiye Rankin skoru 1, dokuz hasta modifiye Rankin Skoru 3, dört hasta modifiye Rankin Skoru 4 ile taburcu edildi. Altı hasta eksitus oldu. Kalan 92 hastanın altı ay sonraki takiplerinde 86 tanesinde tam oklüzyon görülürken altı hastada ikinci girişimle akım yönlendirici stent yerleştirildi.

Sonuç: Yaptığımız çalışmanın sonunda hastalar %81 oranında iyi sonuçla taburcu edilmiş olup mortalite oranı %6'dır. Hastaların %87'sinde tam oklüzyon sağlanmıştır. ICA anevrizmalarında endovasküler tedavi etkin ve güvenlidir. Uygun hasta profilinde cerrahi tedaviye alternatif olarak değerlendirilebilir.

Anahtar Kelimeler: İnternal karotid arter anevrizmaları, akım yönlendirici stent, coil, endovasküler tedavi

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INTRODUCTION

In this study, our primary objective was to investigate the efficacy and potential complications of endovascular treatment in internal carotid artery (ICA) aneurysms. ICA aneurysms account for approximately 28-30% of all aneurysms (1,2) and are more prevalent in women. The most common complaint reported by patients with ICA aneurysms is headaches. Some patients may present with subarachnoid hemorrhage (SAH), while others may present with symptoms associated with compression (drooping eyelids). ICA aneurysms are challenging to operate, although not as intricate as posterior circulation aneurysms. The procedure necessitates both proximal and distal control, requiring meticulous removal of bone structures. Additionally, ICA aneurysms have connections with deep branches that supply critical neural structures.

Surgically treating particularly complex aneurysms (such as fusiform, dissecting, and giant aneurysms) can be challenging and, at times, even impossible. In these patients, longer surgical interventions such as bypass surgery may be needed. In many patients, endovascular therapy may be the only option. Advances in endovascular management have enabled these aneurysms to be treated with lower mortality and morbidity rates. Furthermore, patients treated with endovascular methods experience shorter hospital stays and quicker recovery times compared to open surgery. Moreover, endovascular treatment is considered superior in terms of cost-effectiveness.

For all these reasons, the use of endovascular treatment, which is an alternative to surgical treatment, has increased in this field. Neck-modeling stents, flow-diverting (FD) stents, and coils can be used in endovascular treatment. The most significant complications associated with endovascular treatment are embolism and bleeding. Another drawback of this treatment is the necessity for lifelong use of antiplatelet medications.

MATERIALS and METHODS

The study obtained approval from Adana City Hospital Ethics Committee (Approval number: 2261). The study included 98 patients who presented to our clinic for various reasons (headache, SAH, drooping eyelid) between 2016 and 2022 and were diagnosed with ICA. In addition to the demographic data of the patients, aneurysm location, size, treatment method, complications, occlusion rates and discharge scores were recorded. RROC was used to determine the occlusion rates of the aneurysms, and the mRS was used to evaluate the scores upon discharge.

Antiplatelet loading was administered on the morning of the surgery for patients with bleeding aneurysms and 3-5 days prior to the operation for non-bleeding patients (pre-surgel 10 mg or clopidogrel 75 mg, and acetylsalicylic acid 300 mg). The patients underwent surgery under general anesthesia. Access was gained through the femoral artery using digital subtraction angiography (DSA), and the stent was positioned distal to the aneurysm within the aneurysm dome using microcatheters. Flow diverter stents were deployed via microcatheters to cover the aneurysm. Coils were applied with the catheter within the aneurysm dome when deemed necessary for certain patients.

Of patients presenting with SAH, 24 initially underwent primary coiling and FD stent placement one month later (Figure 1). In these patients, primary coiling was initially performed and stenting was performed one month later to avoid complications (such as hydrocephalus, re-bleeding) that may arise due to bleeding. Forty patients underwent FD stent placement and coiling in the same session (Figure 2). Only FD stents were deployed in four patients. Of 30 patients with incidentally-detected aneurysm, 17 were treated with FD stent placement alone (Figure 3) and 13 with FD stent placement and coiling (Figure 4).



Figure 1. Incidentally-detected aneurysm treated with FD stent and coil in the same session.

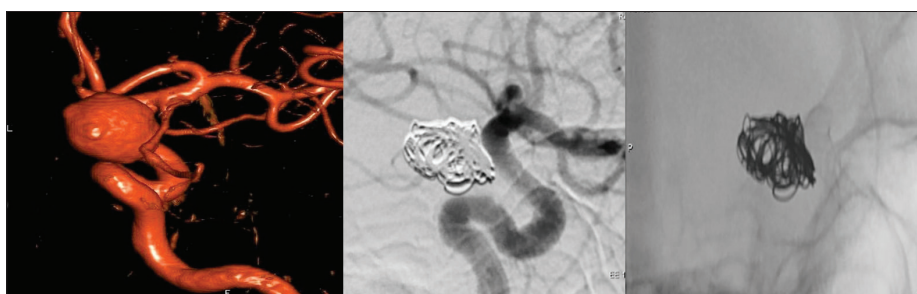


Figure 2. Bleeding aneurysm with primary coiling and FD stent placed in another session.

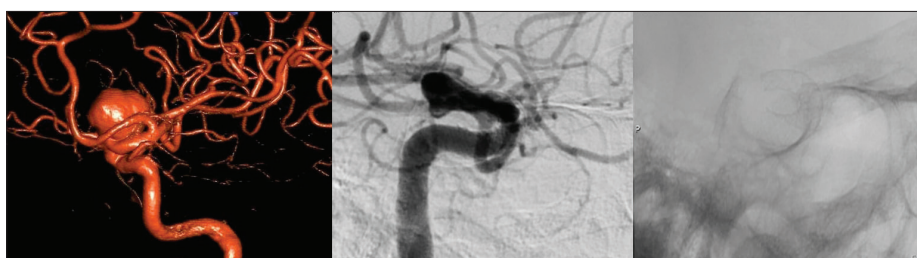


Figure 3. Incidentally-detected aneurysm treated with FD stent alone.



Figure 4. Bleeding aneurysm with coiling and FD stent placed in the same session.

RESULTS

Of the patients, 57 were women and 68 were admitted to the emergency department with SAH. Patients other than those admitted to the emergency department presented to the outpatient clinic with different symptoms. ICA aneurysms were diagnosed incidentally during the investigations. The patients underwent DSA. In addition to ICA aneurysms, DSA revealed additional contralateral ICA in six patients, ipsilateral ICA in eight patients, aneurysms in the anterior communicating artery (AcomA) in three patients, and aneurysms in the middle cerebral artery (MCA) in four patients. Of the aneurysms, two were fusiform enlargement, one was dissecting, the remaining were saccular. Sixteen aneurysms were small (0-5 mm), 68 aneurysms were medium (5-15 mm), 28 aneurysms were large (15-25 mm), and seven aneurysms were giant (>25 mm). Two MCA aneurysms and one AcomA aneurysm were treated using endovascular techniques after a

month. The remaining AcomA and MCA aneurysms were subjected to regular follow-up. Eight patients with ipsilateral ICA aneurysm were treated in the same session. In addition, six patients with additional aneurysms requiring treatment were treated two months later and the remaining seven patients remained under follow-up. During the postoperative period, 73 patients were discharged with an mRS score of 0, six patients with an mRS score of 1, nine patients with an mRS score of 3, and four patients with an mRS score of 4. Six patients died. Of the 92 patients who were followed up, complete occlusion was detected on control DSA performed at six months in 86 patients, whereas two patients had RROC class 2 and another two patients had RROC class 3 occlusion. In six patients without complete occlusion, an FD stent was re-deployed in the same location. Complete occlusion was observed in these patients at 6-18-month control visits (Table 1). Thromboembolism developed in four patients and hemorrhage developed in two patients after treatment.

Table 1. Demographic data of patients and clinical results of treatment

Age		
Age range		(27-82)
Mean age		43.4
Sex		
Man		41
Woman		57
Symptoms		
SAH		68
Incidental (Headache, blurred vision...)		30
Aneurysm morphology (Including additional ICA aneurysms on the same side)		
Saccular		97
Fusiform, dissecting		5
Blister		4
Aneurysm size (Including additional ICA aneurysms on the same side)		
Small (0-5 mm)		11
Medium (5-15 mm)		89
Large (15-25 mm)		6
Giant (>25 mm)		2
Additional aneurysms		
AcomA		3
MCA		4
ICA		
Contralateral		6
Ipsilateral		8
Aneurysm localization (Including additional ICA aneurysms on the same side)		
Cavernous segment		15
Clinoid segment		23
Ophthalmic segment		28
Communicating segment		40
Endovascular treatment		
FD stent		21
FD stent + coil		77
Complication		
Thromboembolism		4
Hemorrhage		2
Outcome score		
mRS 0		73
mRS 1		6
mRS 3		9
mRS 4		4
mRS 6 (Exitus)		6
Occlusion rates in the first six months		
RR Class 1 (Total occlusion)		86
RR Class 2		4
RR Class 3		2

SAH: Subarachnoid hemorrhage, FD: Flow diverter, mRS: Modified Rankin Score, RR: Raymond-Roy, AComA: Anterior communicating artery, MCA: Middle cerebral artery, ICA: Internal carotid artery.

Permanent deficit occurred in one patient experiencing thromboembolism, while the deficits recovered in three patients. One patient with hemorrhage expired, while the other patient did not experience a lasting deficit. Stent occlusion occurred in two patients, and intimal hyperplasia developed in four patients during the follow-up period.

DISCUSSION

Endovascular treatments have been used increasingly in recent times. This trend is attributed to several factors such as the reduced risk of infection for patients, coupled with shorter hospitalization periods and quicker recovery times.

Increasing occlusion rates and its success in the treatment of complex aneurysms have increased its adoption.

The emergence of minimally invasive treatment approaches has led to a heightened interest in endovascular treatment. The brief hospitalization period and minimal infection risk contribute significantly to reduced patient costs, further bolstering its appeal. The aspect of endovascular treatment that receives the most criticism is the low occlusion rates and the requirement for lifelong anticoagulant use in treated patients. Technological advances have effectively elevated occlusion rates to satisfactory levels through the implementation of diverse techniques, yet, anti-coagulant use remains a significant challenge. Despite these concerns, endovascular treatments are gaining prominence, particularly in the context of ICA aneurysms (3).

Internal carotid artery aneurysms are difficult to operate due to their location. In recent years, the success rate in the treatment of aneurysms in this area has increased with the improvements in endovascular treatment (4,5). Dissecting and clipping blister aneurysms situated in this region also pose significant challenges. Due to its dome structure, the aneurysm can easily rupture during clipping and dissection, leading to fatalities (6). In a study of 27 patients with ICA blister aneurysms, patients were treated with FD stenting and an occlusion rate of 92.6% was achieved with 85% of the patients discharged with an mRS of 0-1 (7). In our study, 81% of the patients were discharged with good results (mRS 0-1) and complete occlusion was achieved in 87%.

In another study using FD stent placement in 134 ICA aneurysms, over a follow-up duration of 12 months, the occlusion rate was 79%, the embolism rate was 2.1%, the permanent deficit rate was 0.7%. The study found endovascular interventions effective in the treatment of ICA aneurysms (8).

In another study, 55 patients with ICA aneurysm and neuro-ophthalmological deficits were treated with FD stenting and complete occlusion rate was 72% after 13 months of follow-up. Neuro-ophthalmologic symptoms of 19 patients recovered completely (9). None of the patients in our study exhibited any neuro-ophthalmologic symptoms.

A comprehensive meta-analysis involving the analysis of 41 studies revealed that FD stents yielded a total occlusion rate of 74.6% in cases of small- and medium-sized ICA aneurysms. Additionally, the incidence of complications was notably low (10).

The surgical treatment of giant aneurysms situated in both the anterior and posterior circulation has long been

recognized as being associated with high mortality and morbidity. The large size makes the aneurysm difficult to manipulate and the proximal and distal control impossible. In a study of 44 giant ICA aneurysms treated with either FD stent placement alone or FD stent placement and coiling, an occlusion rate of 72.7% and a complication rate of 2.1% was reported at the end of one year (11).

Another problem seen in ICA aneurysms is the association with other aneurysms. In general, the incidence of multiple aneurysms is reported to be 14-34% in the literature (12-14). Aneurysms located in the same ICA are called tandem aneurysms. These aneurysms are rarely encountered but pose challenges in surgical treatment. The distal aneurysm may rupture while clipping the proximal aneurysm, and the clipping of second aneurysm is challenging. Using endovascular methods, aneurysms located in different segments on the same ICA can be easily treated in the same session. Adeb et al. treated 78 aneurysms in 34 patients with tandem aneurysms and achieved 88.6% complete occlusion at the end of one year. Thromboembolic events occurred in 8.8% of these patients and permanent neurologic deficits developed in 2.9% (15).

In our patient group, nine patients with difficult-to-clip aneurysms due to thin vessel wall, including four patients with blister and five patients with fusiform and dissecting aneurysms, were successfully treated with FD stent placement. Complete occlusion was achieved in these patients after one year of follow-up. Eight patients with tandem ICA aneurysms were treated in a single session, and one of these patients underwent a second FD stent placement six months later due to inability to achieve complete occlusion in the initial session. Six large and two giant aneurysms were treated endovascularly. Of these patients, two died and two patients with incomplete occlusion underwent a second FD stent placement six months later. As a result of all endovascular treatments, six patients died, and 73 patients were discharged with an mRS of 0. Four patients developed thromboembolism and two patients developed hemorrhage. Compared to the literature, the complication and success rates were deemed acceptable.

CONCLUSION

Recently, the use of endovascular interventions has rapidly increased and has opened a new era in the treatment of cerebral aneurysms. Occlusion and complication rates are acceptable in the treatment of ICA aneurysms. In addition, they offer a good alternative in the treatment of giant aneurysms, fusiform and blister aneurysms that are difficult to treat through open surgical methods.

Ethics Committee Approval: The study started with the approval of Adana City Training and Research Ethics Committee (Decision Number: 2261, Date: 17.11.2022).

Author Contributions: Concept/Design: ZB; Analysis/Interpretation: ÜK; Data Acquisition: ZB, ÜK; Writing: ZB; Critical Revision: ÜK; Final Approval: ZB, ÜK.

Conflict of Interest: All authors declare that they have no conflict of interest.

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