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Surgical Management of Ipsilateral Internal Carotid Artery Stenosis and Unruptured Intracranial Aneurysm: Case Review and Treatment Considerations

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Abstract

Introduction The coexistence of carotid artery stenosis and a concomitant downstream ipsilateral unruptured intracranial aneurysm requires unique treatment considerations to balance the risk of thromboembolic complications from carotid artery stenosis and the risk of subarachnoid hemorrhage from intracranial aneurysm rupture. These considerations include the selection of optimal treatment modalities, the order and timing of interventions, and potential management of antiplatelet agents with endovascular approaches. We present strategies to optimize treatment in such a case.

Case Report We discuss the case of a 69-year-old woman with 90% stenosis of the right internal carotid artery and an ipsilateral, wide-necked, 4.8-mm, irregular-appearing right A1–2 junction aneurysm with an associated daughter sac. Open, endovascular, and mixed treatment strategies were considered. The patient selected and underwent a staged, open treatment approach with a carotid endarterectomy followed by a right craniotomy for microsurgical clipping of the aneurysm 5 days later. Both procedures were performed on daily full-dose aspirin without complications. On follow-up, the right carotid artery was widely patent, the aneurysm was secured, and the patient remained at her neurologic baseline.

Discussion The presented strategy for ipsilateral carotid artery stenosis and an unruptured intracranial aneurysm initially optimized cerebral perfusion to mitigate ischemic risks while permitting timely aneurysm intervention without a need for dual antiplatelet therapy or to traverse an earlier procedure site.

Keywords
- carotid artery stenosis
- intracranial aneurysm
- staged treatment
- carotid endarterectomy
- microsurgical clipping

Introduction

The coexistence of an ipsilateral unruptured intracranial aneurysm (UIA) in the setting of significant cervical internal carotid artery (ICA) stenosis occurs in approximately 3.2% of cases.[1,2] These concomitant pathologies require unique treatment considerations, including the appropriate selection of endovascular, open surgical, or hybrid technique as well as timing the procedure to mitigate both ischemic and hemorrhagic risks and managing the use of antiplatelet agents. Treating the ICA stenosis before securing the coexisting aneurysm may alter intracranial hemodynamics and thereby increase aneurysm rupture risk.[3,4] Conversely, UIA

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treatment before ICA stenosis management may increase the risk of perioperative stroke from hypoperfusion and/or traversing catheters/wires through a stenotic ICA.[5] Moreover, the potential need for dual antiplatelet therapy (DAPT) after endovascular aneurysm treatments that require stenting or flow diversions must be considered with any subsequent open surgical intervention.

There is no consensus treatment and limited evidence regarding the safest, most effective treatment strategy for this patient population. We present a patient with ipsilateral ICA stenosis and an A1–2 intracranial aneurysm who underwent a successful, staged, open carotid endarterectomy (CEA) and microsurgical aneurysm clipping to demonstrate the rationale for this approach.

Case Report

History

A 69-year-old woman with a history of myocardial infarction, hypertension, hyperlipidemia, hypothyroidism, and Bell's palsy with a residual right-sided facial droop developed diplopia, headaches, and mild difficulty walking after a ground-level fall. A head computed tomography (CT) scan demonstrated no acute findings. Magnetic resonance imaging (MRI) and CT angiography (CTA) demonstrated multifocal atherosclerotic disease and an intracranial aneurysm, prompting a neurosurgical consultation. In the neurosurgery clinic, the patient reported improved diplopia, mild dizziness, and headaches. Her neurologic examination was unremarkable, aside from a chronic right-sided facial droop. She was taking low-dose aspirin, clopidogrel, and a statin for her atherosclerotic disease.

Preoperative Neuroimaging

Brain MRI revealed scattered microvascular ischemic changes but no acute strokes. CTA and diagnostic cerebral angiogram demonstrated bilateral proximal ICA stenosis (right 90%, left 65%), multifocal left vertebral artery stenosis (proximal 77%, V4 50%), and mild scattered intracranial atherosclerotic disease. A wide-necked, 4.8-mm aneurysm with multiple secondary excrescences was seen arising from the right A1–2 region with a small, poorly visualized anterior communicating artery (Acomm) (►**Fig. 1**).

Preoperative Assessment and Patient Counseling

Treatment for both pathologies was recommended after multidisciplinary review, with proposed treatment of the ICA first and subsequent aneurysm treatment as soon as safely possible thereafter. Open, endovascular, and hybrid options were discussed with the patient, who selected a staged, open surgical strategy. Her antiplatelet regimen was switched to full-dose aspirin monotherapy in preparation for surgery.

Treatment and Outcome

A right CEA was performed first, followed by a second-stage right frontotemporal craniotomy for microsurgical aneurysm clipping 5 days later. Both procedures were performed without complications. The patient was admitted to the neurocritical care unit after each procedure (with strict blood pressure control of 110–140 mm Hg between stages). A carotid duplex ultrasound after CEA demonstrated ICA patency. This was confirmed on CTA after the craniotomy, which also demonstrated no residual aneurysm or strokes. The patient was discharged 1 week after the craniotomy at her neurologic baseline and remained neurologically stable with unchanged imaging over 3-month follow-up (►**Fig. 2**).

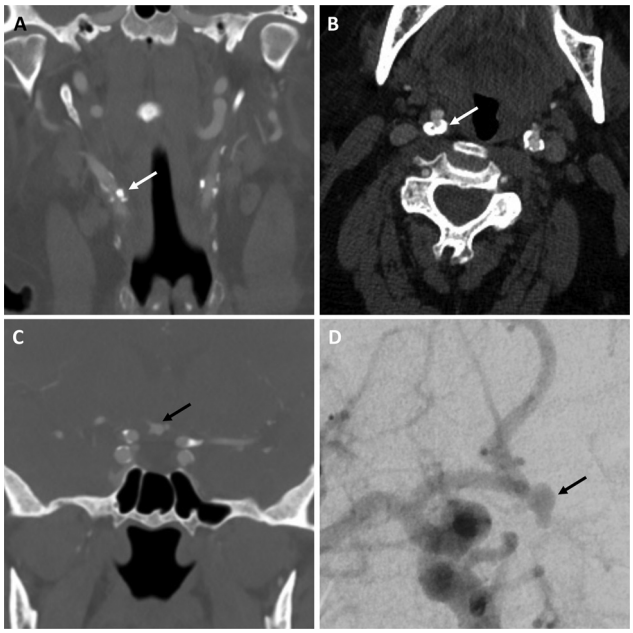

Fig. 1 Preoperative imaging. A 69-year-old woman was found to have a high-grade right ICA stenosis and an ipsilateral unruptured intracranial aneurysm on workup for headache, dizziness, and diplopia. Coronal (**A**) and axial (**B**) CTA demonstrated a calcified atherosclerotic plaque resulting in 90% stenosis of the right ICA (white arrows). Coronal CTA (**C**) and right ICA injection oblique view on digital cerebral angiography (**D**) showing a wide-necked (2.9-mm neck, 4.8-mm dome) anterior–inferior projecting aneurysm with multiple secondary excrescences arising from the right A1–2 region (black arrows). CTA, computed tomography angiography; ICA, internal carotid artery.

Discussion

In cases of concomitant ICA stenosis and a UIA, the risk of embolic stroke and ischemia from carotid artery stenosis must be balanced with the risk of aneurysmal subarachnoid hemorrhage (aSAH). UIAs have an annual rupture risk of 1 to 3%, and the mortality rate is up to 50% in the setting of aSAH.[6,7] Rupture risk is associated with aneurysm size (>7 mm), smoking, female sex, hypertension, and a family/personal history of aSAH.[8,9] Aneurysms within the posterior circulation, those in the Acomm region, and those with irregular angioarchitecture also carry more risk.[9,10] In the presented case, the aneurysm diameter (4.8 mm), irregular shape, associated daughter sac, and Acomm region location prompted treatment.

Carotid artery stenosis is a similarly nonbenign condition and an independent risk factor for ischemic stroke.[11] A CEA or carotid artery stent (CAS) is generally recommended for asymptomatic patients with stenosis ≥ 60% or symptomatic

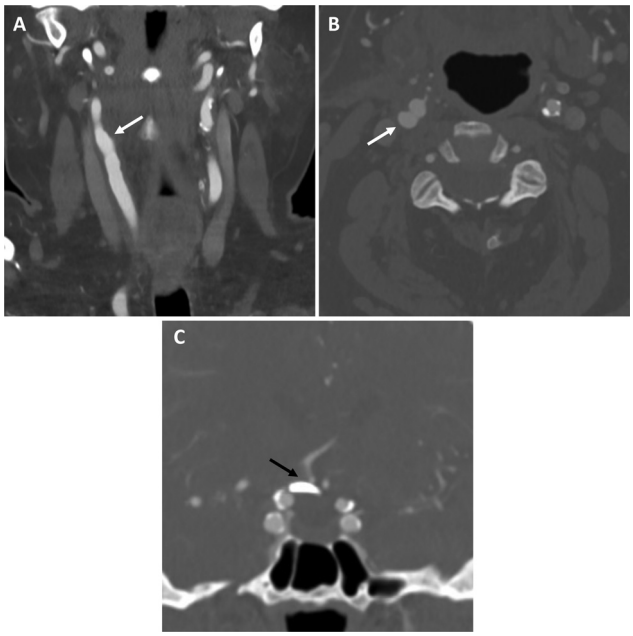

Fig. 2 Follow-up imaging. The patient was treated successfully with a staged right carotid endarterectomy followed by microsurgical aneurysm clipping 5 days later. Follow-up CTA imaging demonstrated wide patency of the right ICA (white arrows on coronal [**A**] and axial [**B**] CTA) and no residual aneurysm (black arrow on coronal CTA [**C**]). CTA, computed tomography angiography; ICA, internal carotid artery.

patients with stenosis $\geq$50%.[12,13] Our patient presented with >90% asymptomatic stenosis and met criteria for treatment.

Treatment options for concomitant lesions typically address the carotid disease first to avoid ischemic complications and include CEA with open microsurgical aneurysm clipping (commonly staged), CAS plus staged or simultaneous endovascular aneurysm treatment (coiling, stent-coiling, flow diversion, or intrasaccular device), CEA plus staged or simultaneous endovascular aneurysm treatment, CAS followed by delayed clipping of the aneurysm (after a period of DAPT), and isolated CEA or CAS followed by close monitoring of the aneurysm. Each strategy has advantages and disadvantages stemming from the distinct clinical scenario.

With staged approaches, the timing between stages requires consideration, because there is a greater theoretical risk of rupture of downstream aneurysms after carotid revascularization from increased hemodynamic pressure and disruptions in autoregulation.[3,4,14] The associated risks and optimal treatment timing in this setting nonetheless remain unclear.[15–17] In a subgroup analysis of 32 patients from the North American Symptomatic Carotid Endarterectomy Trial who underwent carotid revascularization with a concurrent UIA, only one patient experienced aSAH within 30 days of revascularization.[1] Similarly, in a retrospective study of 198 patients who underwent carotid revascularization with a concomitant UIA, one patient experienced aSAH within 30 days of CEA, and two patients experienced aSAH more than 30 days after CEA, with an overall 0.87% risk of rupture per patient year.[15] Given these data, Tallarita et al[15] argued that the risk of aneurysmal rupture is not imminent after CEA, and treatment of an aneurysm may be delayed if indicated. However, neither of these studies was limited to patients with ipsilateral aneurysms/carotid stenosis, where the risk of rupture is theoretically the highest. In a systematic review, Khan et al[18] reported that 5/140 (4%) patients who underwent carotid revascularization experienced rupture of a coexisting UIA, with ipsilateral stenosis and UIA carrying the highest risk. In our case, CEA and microsurgical aneurysm clipping were performed within a 5-day span (with blood pressure strictly controlled between surgeries) to mitigate rupture risk, while also allowing for recovery from the initial surgery and anesthesia. A shorter interval timeframe (i.e., between 2 and 4 days) could, nonetheless, have been selected with likely similar results.

Hybrid open and endovascular options also exist, most commonly with CEA followed by a staged endovascular aneurysm treatment.[15] A nonstaged hybrid approach has also been reported, with simultaneous CEA and ipsilateral intracranial aneurysm coiling in a patient with 90% stenosis of a tortuous left ICA and an Acomm aneurysm.[2] However, this approach is technically challenging, requires use of a hybrid operating room, and involves crossing a freshly repaired ICA with a sheath.

Endovascular treatment of both lesions is yet another possible management strategy, particularly in patients on DAPT for other reasons. If pursued, CAS is typically performed before the aneurysm treatment because traversing a significant stenosis with endovascular devices before carotid revascularization may increase the risk of thromboembolic complications.[19] Although this approach can be performed simultaneously or in a staged fashion, staged treatment (of at least 3 weeks) is preferred to allow for neointimal growth within the stent, with careful interval blood pressure management.[14] In cases of noncritical ICA stenosis and a stable plaque, first-line endovascular aneurysm treatment with a subsequent CAS up to 1 month later has also been reported.[20]

Single-stage endovascular treatment of both lesions may also be performed. Kaçar et al[21] reported a series of seven patients treated with simultaneous CAS and endovascular aneurysm securement; they reported no hemorrhagic events or technical failures except one contralateral transient ischemic attack, and all aneurysms were adequately occluded on follow-up imaging. Similarly good results were reported with this technique by Ni et al[22] in a series of 10 patients. Park et al[19] also demonstrated this method's effectiveness in a series of 17 patients, although complications occurred in 11.7% of patients, namely acute in-stent thrombosis and premature aneurysmal rupture.

Although not as common, UIA treatment before carotid revascularization can also mitigate the risk of aneurysm rupture. In this strategy, the patient has a theoretical risk of perioperative cerebral ischemia from reduced cerebral perfusion secondary to the carotid stenosis, particularly if bilateral carotid stenosis is present.[5] A retrospective series of 60 patients nonetheless suggests this can be a safe strategy.[23] CAS followed by a delayed microsurgical clipping of the aneurysm is less common but viable option. However, the need for DAPT after CAS (typically for at least 6 months, which can limit treatment options in case of aneurysm

rupture) and its associated hemorrhage risk must be considered.[24,25]

Isolated carotid disease treatment with close aneurysm monitoring can also be pursued. Although the risk of aneurysm rupture with this strategy is relatively low (ranging from 0 to 5.3%),[2] this approach is likely best suited for relatively small aneurysms without high-risk features and should include close blood pressure monitoring.

Conclusion

Multiple management strategies for concomitant ICA stenosis and UIAs exist. Selection of treatment approaches and timing should be tailored to the patient to minimize ischemic and hemorrhagic risks. Although permutations of the endovascular options are increasingly preferred, in our case, a staged open strategy was selected to optimally minimize ischemic and hemorrhagic risks.

Declaration of Patient Consent

The authors certify that they have obtained all appropriate patient consent.

Conflict of Interest

None declared.

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References

1 Kappelle LJ, Eliasziw M, Fox AJ, Barnett HJNorth American Symptomatic Carotid Endarterectomy Trial Group. Small, unruptured intracranial aneurysms and management of symptomatic carotid artery stenosis. Neurology 2000;55(02):307–309
2 Korotkikh AV, Nekrasov DA, Khilchuk AA, Scherbak SG, Sarana AM. Simultaneous internal carotid artery stenosis and ipsilateral anterior communicating artery saccular aneurysm treatment: a case report. Radiol Case Rep 2020;15(07):1083–1086
3 Shakur SF, Amin-Hanjani S, Bednarski C, et al. Intracranial blood flow changes after extracranial carotid artery stenting. Neurosurgery 2015;76(03):330–336
4 Shakur SF, Hrbac T, Alaraj A, et al. Effects of extracranial carotid stenosis on intracranial blood flow. Stroke 2014;45(11):3427–3429
5 Ballotta E, Da Giau G, Manara R, Baracchini C. Extracranial severe carotid stenosis and incidental intracranial aneurysms. Ann Vasc Surg 2006;20(01):5–8
6 Wiebers DO, Whisnant JP, Huston J III, et al; International Study of Unruptured Intracranial Aneurysms Investigators. Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment. Lancet 2003;362 (9378):103–110
7 Stienen MN, Germans M, Burkhardt JK, et al; Swiss SOS Study Group. Predictors of in-hospital death after aneurysmal subarachnoid hemorrhage: analysis of a nationwide database (Swiss SOS [Swiss Study on aneurysmal subarachnoid hemorrhage]). Stroke 2018;49(02):333–340
8 Vlak MH, Algra A, Brandenburg R, Rinkel GJ. Prevalence of unruptured intracranial aneurysms, with emphasis on sex, age, comorbidity, country, and time period: a systematic review and meta-analysis. Lancet Neurol 2011;10(07):626–636
9 Wermer MJ, van der Schaaf IC, Algra A, Rinkel GJ. Risk of rupture of unruptured intracranial aneurysms in relation to patient and aneurysm characteristics: an updated meta-analysis. Stroke 2007;38(04):1404–1410
10 Bijlenga P, Ebeling C, Jaegersberg M, et al; @neurIST Investigators. Risk of rupture of small anterior communicating artery aneurysms is similar to posterior circulation aneurysms. Stroke 2013; 44(11):3018–3026
11 Petty GW, Brown RD Jr, Whisnant JP, Sicks JD, O'Fallon WM, Wiebers DO. Ischemic stroke subtypes: a population-based study of incidence and risk factors. Stroke 1999;30(12):2513–2516
12 Barnett HJ, Taylor DW, Eliasziw M, et al; North American Symptomatic Carotid Endarterectomy Trial Collaborators. Benefit of carotid endarterectomy in patients with symptomatic moderate or severe stenosis. N Engl J Med 1998;339(20):1415–1425
13 Bonati LH, Kakkos S, Berkefeld J, et al. European Stroke Organisation guideline on endarterectomy and stenting for carotid artery stenosis. Eur Stroke J 2021;6(02):I–XLVII
14 Wajima D, Nakagawa I, Wada T, Nakase H. A trial for an evaluation of perianeurysmal arterial pressure change during carotid artery stenting in patients with concomitant severe extracranial carotid artery stenosis and ipsilateral intracranial aneurysm. Turk Neurosurg 2019;29(05):785–788
15 Tallarita T, Sorenson TJ, Rinaldo L, et al. Management of carotid artery stenosis in patients with coexistent unruptured intracranial aneurysms. J Neurosurg 2019;132(01):94–97
16 Siddiqui A, Vora N, Edgell RC, Callison RC, Kitchener J, Alshekhlee A. Rupture of a cerebral aneurysm following carotid endarterectomy. J Neurointerv Surg 2012;4(05):e27
17 Riphagen JH, Bernsen HJ. Rupture of an intracerebral aneurysm after carotid endarterectomy: a case report. Acta Neurol Belg 2009;109(04):314–316
18 Khan UA, Thapar A, Shalhoub J, Davies AH. Risk of intracerebral aneurysm rupture during carotid revascularization. J Vasc Surg 2012;56(06):1739–1747
19 Park JC, Kwon BJ, Kang HS, et al. Single-stage extracranial carotid artery stenting and intracranial aneurysm coiling: technical feasibility and clinical outcome. Interv Neuroradiol 2013;19 (02):228–234
20 Iwata T, Mori T, Tajiri H. Successful staged endovascular treatment of a symptomatic cervical carotid bifurcation stenosis coupled with a coincidental unruptured cerebral aneurysm in the carotid distal segment. AJNR Am J Neuroradiol 2008;29(10): 1948–1950
21 Kaçar E, Nas ÖF, Erdoğan C, Hakyemez B. Single-stage endovascular treatment in patients with severe extracranial large vessel stenosis and concomitant ipsilateral unruptured intracranial aneurysm. Diagn Interv Radiol 2015;21(06):476–482
22 Ni H, Zhong Z, Zhu J, et al. Single-stage endovascular treatment of severe cranial artery stenosis coexisted with ipsilateral distal tandem intracranial aneurysm. Front Neurol 2022;13:865540
23 Illuminati G, Missori P, Hostalrich A, Chaufour X, Nardi P, Ricco JB. Retrospective multicenter study on the management of asymptomatic carotid artery stenosis with coexistent unruptured intracerebral aneurysm. J Vasc Surg 2022;76(05):1298–1304
24 Higashiguchi S, Sadato A, Nakahara I, et al. Reduction of thromboembolic complications during the endovascular treatment of unruptured aneurysms by employing a tailored dual antiplatelet regimen using aspirin and prasugrel. J Neurointerv Surg 2021;13 (11):1044–1048
25 Palmerini T, Bruno AG, Redfors B, et al. Risk-benefit of 1-year DAPT after DES implantation in patients stratified by bleeding and ischemic risk. J Am Coll Cardiol 2021;78(20):1968–1986