A 61-year-old man presented with acute dysarthria, weakness, and clumsiness of his left hand. Symptoms lasted 10 minutes and resolved completely. The patient denied having any other associated symptoms. He had a 40-pack-year history of cigarette smoking, controlled hypertension, hypercholesterolemia, migraine headache, aortic stenosis, and coronary artery bypass grafting after a myocardial infarction 16 years previously. His coronary artery disease was stable, and he denied having any prior history of stroke or transient ischemic attack (TIA). The patient took 325 mg of aspirin daily. Findings on general physical and neurologic examinations were normal except for a grade 2/6 aortic stenosis murmur. Carotid duplex ultrasonography demonstrated a 60% to 79% stenosis of the right internal carotid artery (ICA) that was 2.0 cm distal to the common carotid artery bifurcation, with minimal disease of the left ICA. Three-vessel cerebral angiography confirmed the high-grade right ICA stenosis (Figure 1, A). Findings on head computed tomography and brain magnetic resonance imaging were normal. Laboratory tests yielded a normal complete blood cell count, glucose level, erythrocyte sedimentation rate, prothrombin time, and activated partial thromboplastin time.

1. Which one of the following is the most likely cause of this patient’s spell?
   a. Focal seizure
   b. Symptomatic right ICA distribution TIA
   c. Symptomatic left ICA distribution TIA
   d. Complicated migraine
   e. Hypoglycemia

Unilateral sensory, motor, or sensorimotor symptoms can be due to focal seizures. However, seizures typically manifest with phenomena such as tingling, excessive motor activity, or both rather than numbness or weakness. The duration of ictus is usually less than 5 minutes except in prolonged seizures or status epilepticus. Retained awareness during the ictus is typical for simple partial seizures. Some degree of altered awareness and amnesia accompanies complex partial seizures. A TIA is defined as a focal neurologic deficit related to ischemia, lasting less than 24 hours. The high-grade right ICA stenosis seems responsible for our patient’s symptoms and would be classified as a symptomatic carotid artery stenosis. However, vertebrobasilar ischemia could produce similar symptoms. Symptomatic left ICA stenosis would result in right-sided symptoms. Complicated migraine may produce focal neurologic symptoms, but headache is usually a prominent feature. Hypoglycemia-associated focal neurologic symptoms occur in the setting of a low serum glucose level (<40 mg/dL) and abnormal or normal mental state.

A combination of carotid endarterectomy, risk factor reduction, and antiplatelet therapy for symptomatic carotid artery stenosis has been shown in randomized controlled trials to be superior to medical management alone in selected patients in whom surgical morbidity and mortality are less than 6%.

The patient underwent right carotid endarterectomy (CEA) with removal of an atheromatous calcified ulcerative plaque. The operative report stated that 2 double-armed 6-0 prolene sutures were placed at the distal intimal break point to prevent subintimal dissection. The arteriotomy was then closed primarily. The patient experienced no postoperative complications and was discharged 3 days later; he continued taking 325 mg of aspirin daily. Anti-hypertensive and lipid-lowering agents were continued.

The patient was admitted to the hospital 1 week later because of multiple stereotypical episodes of weakness and clumsiness of his left arm, each lasting 5 to 10 minutes. Findings on neurologic and general physical examinations were normal, as were results of head computed tomography. Three-vessel cerebral angiography showed progressive tapering of the right ICA, culminating in occlusion 15 mm distal to its origin (Figure 1, B). Reconstitution of the right middle cerebral and anterior cerebral arteries was achieved by collateral blood flow via the left ICA and anterior communicating artery (Figure 1, C). There was also minor collateralization to the right ophthalmic artery via the right external carotid artery. The complete blood cell count, prothrombin time, activated partial thrombo-
plastin time, and platelet count were normal. While in the hospital, the patient experienced 2 more episodes of recurrent symptoms in his left arm that persisted for 5 minutes each, with no residual neurologic deficit.

2. Which one of the following is the most likely mechanism of this patient’s right ICA occlusion?
   a. Neointimal fibromuscular hyperplasia
   b. Proliferation of smooth muscle cells
   c. Recurrent atherosclerosis
   d. Postoperative dissection and thrombosis
   e. Hypercoagulable state leading to thrombosis

   The frequency of restenosis after CEA varies and depends on factors such as definition of recurrent disease, length of follow-up, and surgical technique used.\(^3\) In a prospective study, the frequency of asymptomatic mild to moderate restenosis was 10%, and for severe stenosis or occlusion, it was 3%.\(^3\) The pathologic features of early and late recurrent stenosis differ. Restenosis after the first month but less than 3 years postoperatively is predominantly associated with neointimal fibromuscular hyperplasia and proliferation of smooth muscle cells, whereas late recurrence (>3 years after surgery) has elements of atherosclerosis (foam cells, cholesterol crystals, abundant collagen, and calcium).\(^4\) The presence of restenosis in the first postoperative month is most commonly caused by a technical surgical error, which may lead to dissection and thrombosis, or residual atherostenosis.\(^5\) Heparin-induced hypercoagulability has also been implicated as a cause of postoperative carotid occlusion.\(^6\) This complication should be suspected in patients who develop thrombocytopenia associated with postoperative ischemia.

   The transient symptoms of the patient’s left hand most likely resulted from occlusion and thrombosis of the right ICA with distal embolization. Good collateral flow from the left ICA prevented a right hemispheric stroke. The patient was treated with heparin and was discharged; warfarin was continued. The day after discharge, he experienced 2 more episodes of numbness and weakness of his left hand, lasting less than 5 minutes. He was examined the next day after having a 3-minute episode of a stereotypical spell. His blood pressure (150/80 mm Hg) and findings on general physical, neurologic, and ophthalmologic examinations were normal. The international normalized ratio was 2.1. The spells ceased after his antihypertensive medication was discontinued, and his systolic blood pressure was maintained between 160 and 180 mm Hg and diastolic pressure between 90 and 100 mm Hg.

   Nine months later, the patient experienced 4 episodes of right visual disturbance over a period of 1 month; he described these as visual blurring with black spots affecting the right eye and twitching of the eyelid. Each episode lasted 2 to 4 minutes and completely resolved. Neuro-ophthalmologic examination showed a visual acuity of 20/30–2 on the right, and 20/20–1 on the left. Findings on a visual field examination were normal, but a funduscopic examination revealed a small cholesterol plaque nasal to the distal branch of the right retinal artery. A second cerebral angiogram demonstrated right ICA occlusion with a “stump” 2 cm distal to the cervical carotid bifurcation. The ipsilateral external and common carotid vessels and contralateral carotid system were patent.

3. Which one of the following most likely caused the right-sided visual symptoms experienced by our patient?
   a. Occlusion of the right external carotid artery
   b. Proximal ICA stump emboli via the right ophthalmic artery
   c. Left posterior circulation TIA
   d. Giant cell arteritis
   e. Carotid dissection

   Occlusion of the ICA at a site distal to the bifurcation may result in formation of a stump. Turbulence in the stump is thrombogenic and may produce distal or proximal embolization via the anastomotic arteries.\(^7\) Proximal emboli from the right carotid stump via the ophthalmic artery were most likely responsible for the amaurosis fugax seen in this patient. Left posterior cerebral artery TIA would be expected to result in homonymous hemianopia. Although giant cell arteritis and carotid dissection can cause mono-ocular transient symptoms such as those seen in our patient, neither is a probable cause based on this patient’s clinical history and examination findings.

   The patient underwent a right carotid stumpectomy (resection and oversewing of the ICA origin), with complete resolution of his right amaurosis fugax. Intraoperatively, fresh thrombus was identified in the ICA stump. Warfarin was continued. Twelve months later while he was receiving therapeutic oral anticoagulant therapy, the patient noted “bilateral visual blurring” and “rubbery legs,” which lasted 20 seconds. Findings on general physical, neurologic, and ophthalmologic examinations were unremarkable, as were findings on brain magnetic resonance imaging, transthoracic echocardiography, and electrocardiography. Magnetic resonance angiography of the head and neck showed 70% to 90% stenosis of the left ICA and the previously known occluded right ICA. Carotid duplex ultrasonography confirmed the high-grade left ICA stenosis. The cause of the patient’s transient spell of bilateral visual blurring and rubbery legs is unknown. Vertebrobasilar transient ischemia, global cerebral hypoperfusion, and hypoglycemia may produce similar symptoms. His left ICA stenosis was thought to be asymptomatic.
Figure 1. A, Arteriogram showing high-grade stenosis (arrow) of right internal carotid artery (R ICA). B, Arteriogram showing occlusion (arrow) of R ICA. C, Arteriogram of left ICA demonstrating filling of the right middle cerebral artery by collateral flow via left ICA and anterior communicating artery.

4. Which one of the following is not a reasonable management option for this patient’s high-grade left cervical carotid artery stenosis?
   a. CEA
   b. Risk factor management
   c. Antiplatelet therapy
   d. Carotid angioplasty and stenting
   e. Extracranial-intracranial bypass surgery

   Treatment options for asymptomatic high-grade (>60%) carotid artery stenosis can be broadly divided into medical and surgical therapies. The Asymptomatic Carotid Atherosclerosis Study, a multicenter prospectively randomized study, showed benefit in favor of the best medical therapy and CEA (5.1%) versus medical treatment alone (11.0%) over 5 years for ipsilateral stroke when the risk of surgical morbidity and mortality is less than 3%. Patient selection is crucial. Elderly patients with limited life expectancy and multiple comorbidities have an increased surgical risk. For patients with unacceptable surgical risk, medical management of risk factors and use of antiplatelet agents are other therapeutic considerations. In a prospective, nonrandomized study, percutaneous carotid angioplasty and stenting were shown to be feasible and safe in a group of patients with severe carotid stenosis who were considered high risk for endarterectomy. However, the long-term outcome and efficacy of this procedure in the treatment of asymptomatic carotid stenosis remain unknown. Currently, extracranial-intracranial bypass is not a viable treatment option for management of asymptomatic cervical carotid artery stenosis.

   Follow-up evaluation of our patient 6 months later with magnetic resonance angiography showed progressive stenosis (80% to 99%) of the left ICA. A 3-vessel cerebral angiogram confirmed 85% stenosis of the left ICA (Figure 2, A and B). The patient’s entire anterior circulation depended on this vessel. The left external carotid artery contributed substantially to the posterior circulation via collaterals to the left vertebral artery. Therefore, he was considered high risk for CEA. Balloon angioplasty of the left ICA with placement of a stent at the site of maximal narrowing was performed without complication at the time of angiography. The patient was discharged the next day; his medications were clopidogrel, 75 mg daily, and aspirin, 325 mg twice daily. At follow-up evaluation 1 month later, he was doing well.

5. Which one of the following was the most powerful independent factor responsible for the development and progression of carotid atherosclerosis in this patient?
   a. Male gender
   b. Hypertension
   c. Hyperlipidemia
   d. Hyperhomocysteinemia
   e. Cigarette smoking

   The independent determinants of carotid atherosclerosis include age, male gender, hypertension, increased cholesterol and plasma homocysteine levels, and cigarette smoking. The prevalence of stroke and carotid disease increases dramatically in persons older than 75 years, but smoking is the most powerful independent factor associated with the development and progression of carotid atherosclerosis in younger patients.

DISCUSSION

Our case illustrates 2 important points. First is the wide spectrum of diagnostic and therapeutic challenges encountered in managing patients with carotid artery disease. Second, carotid atherosclerosis similar to coronary atherosclerosis is not a monophasic disease. Primary closure instead
of patch closure of the arteriotomy site increases the likelihood of residual disease. Of importance, the vessel must be reconstructed in such a manner that no kinks or obstruction to flow is present after endarterectomy. Obtaining a satisfactory distal intimal break point in the ICA cannot be overemphasized. Occasionally, placement of intimal tack sutures is necessary (as was done in our patient), but this approach does not guarantee that a subintimal dissection cannot occur if the endarterectomy is not extended to healthy intima. The endarterectomized surface is highly thrombogenic for the first 4 hours after endarterectomy. For this reason, our practice is to not reverse the heparin given during the period of intraoperative carotid occlusion.

Several reports, including population-based studies, have demonstrated similar risk factors for coronary and carotid atherosclerosis. Aggressive risk factor management after surgery is as important as surgical technique in reducing the risk of recurrent disease. Distinguishing symptomatic from asymptomatic carotid stenosis has practical and therapeutic implications, and establishing an accurate diagnosis of transient neurologic symptoms is essential. Timing of the evaluation of carotid artery patency after endarterectomy varies but should be assessed at least once in the first postoperative year, especially in patients with risk factors for disease progression. At Mayo Clinic Rochester, carotid ultrasonography is commonly used, but oculoplethysmography and transcranial Doppler ultrasonography are other acceptable methods of assessing carotid artery patency after CEA. The role of long-term antiplatelet therapy and lipid-lowering agents in reducing the incidence of restenosis in these patients is unknown.

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REFERENCES


Correct answers: 1. b, 2. d, 3. b, 4. e, 5. e