Original Paper

Management of Bilateral Carotid Occlusive Disease

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Key Words

Acute stroke · Carotid occlusion · Intervention · Revascularization

Abstract

Background: Symptomatic bilateral internal carotid occlusive disease is a rare but potentially devastating entity. Medical therapy alone is associated with high rates of mortality and recurrent stroke. The optimal management of this disease remains poorly understood. **Methods:** A retrospective review of a prospectively maintained database was conducted for patients who presented with an acute stroke in the setting of bilateral carotid occlusive disease between May and October 2013. **Results:** We identified 3 patients. The admission National Institutes of Health Stroke Scale score ranged from 4 to 7. All patients had small- to moderate-sized infarcts in the anterior circulation on presentation. Angiography confirmed bilateral internal carotid occlusions with collateral filling via the posterior communicating artery and retrograde filling via external carotid artery supply to the ophthalmic artery. All patients were initially managed with permissive hypertension and anticoagulation followed by carotid angioplasty and stenting. At 1-year follow-up, all patients demonstrated a modified Rankin scale score of 0–1. **Conclusions:** Carotid stenting may be a safe and effective therapy for patients presenting with symptomatic bilateral carotid occlusions.

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Introduction

The natural history of unilateral chronic carotid occlusion is relatively well understood, with a low risk of events in asymptomatic lesions [1] and a stroke rate as high as 26.5% at 2 years in patients with increased oxygen extraction fraction on PET imaging (stage II hemodynamic failure) [2]. A recent study of extracranial-intracranial bypass in patients with impaired

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oxygen extraction fraction in the setting of symptomatic occlusive carotid disease revealed no benefit at 2 years in patients undergoing surgery versus best medical therapy [3]. Patients with bilateral carotid occlusion were excluded from the Carotid Occlusion Surgery study as PET imaging cannot be reliably applied as selection criteria in the context of bihemispheric disease. The best management of this subset of patients is unclear [4].

Bilateral carotid occlusive disease is far less common than unilateral carotid occlusive disease, with a series of 212 cases of internal carotid artery (ICA) occlusive disease identifying 8 cases of bilateral occlusion (3.8%) [5]. A meta-analysis including 70 patients with bilateral occlusions revealed a 20% rate of recurrent stroke in this population [6]. In a series of 21 patients with a mean follow-up of 6 years, the mortality for symptomatic bilateral carotid occlusive disease was 52%. Surgical revascularization (via carotid endarterectomy or bypass) was associated with lower rates of death, suggesting that revascularization may lead to improved outcomes over medical management [6].

Carotid stenting has previously been reported for the management of acute, subacute and chronic unilateral symptomatic carotid occlusive disease with a good safety profile and high rates of revascularization [7–17]. Here, we report on the application of carotid stenting for the management of symptomatic bilateral carotid occlusive disease.

Methods

A retrospective review of a prospectively maintained database identified 3 patients who presented to the University of Pittsburgh Medical Center between May and October 2013 with acute ischemic stroke in the setting of bilateral carotid occlusions. All patients underwent baseline MRI of the head confirming moderate-sized (20–30 ml) infarcts in the anterior circulation consistent with their clinical symptoms. Additional testing with CT perfusion was performed to confirm that additional parenchyma was at risk for future ischemic injury. All patients were initially managed medically with permissive hypertension and anticoagulation. Catheter-based angiography was performed to confirm occlusion of the ICA. Dedicated views of the external carotid artery and injections from the posterior circulation were performed to assess the presence and quality of collateral circulation.

Carotid angioplasty and stenting were performed on the symptomatic side (cases 1 and 2) or both sides (case 3). All patients were loaded with 600 mg of clopidogrel and 325 mg of aspirin on the day prior to the procedure. Prior to stenting, heparin was administered to achieve an activated clotting time of at least 250 s. Through a diagnostic catheter, an Amplatz wire (Cook Medical) was placed in the external carotid artery. Over the Amplatz wire, a 6-Fr Neuron Max sheath (Penumbra) was exchanged into the common carotid artery. A V18 control wire (Boston Scientific) was then advanced into the ICA stump to explore the vessel and establish a conduit to the distal petrous carotid artery. Over this wire, an 18L microcatheter (eV3) was placed in the distal petrous ICA. The V18 control wire was removed, and a gentle microinjection was performed to confirm the patency of the ICA distal to the petrous segment. An exchange length 014 Synchro microwire (Boston Scientific) was then advanced into the 18L microcatheter up to the level of the cavernous carotid. The 18L microcatheter was then removed, and over the Synchro microwire, a 5-Fr SpiderFx distal protection device (Boston Scientific) was advanced to the proximal cavernous carotid and deployed.

At this point, a gentle injection through the Neuron Max shuttle catheter was performed to confirm focal high-grade carotid stenosis in the proximal ICA. Administration of 1 mg of atropine was followed by pre-stent angioplasty with a 3-mm balloon (Viatrix, Abbott Vascular). A 6–8 × 40-mm Xact stent (Abbott Vascular) was then placed across the ICA stenosis followed by post-stent placement angioplasty with a 5-mm balloon (Maverick, Boston Scientific). Intracranial views of the anterior circulation were then performed to confirm the patency of the vessels and absence of distal embolization. The distal embolization device was then recovered. All procedures were performed via transfemoral access, and groin hemostasis was achieved with a 6-Fr Angio-Seal closure device (St. Jude Medical).

All patients were monitored in the Neurocritical Care Unit with aggressive blood pressure control (goal systolic blood pressure <140 mm Hg). Outcomes were measured at discharge using the modified Rankin scale (mRS).

Fig. 1. MRI head reveals an area of restricted diffusion in the right frontal lobe (**a**). Sagittal projection of the right internal carotid on day 2 reveals an occluded vessel (**a, b**). On day 7, the right ICA recanalizes (**b, c**) at which point, a carotid stent is successfully placed (**c, d**). A right anterior oblique view of the head reveals good flow in both hemispheres after stent placement (**d, e**). Post-procedural CT of the head reveals stable stroke burden (**f**).

Table 1. Patient characteristics with clinical data

Patient No.	Age, years	NIHSS score	Symptomatic side	Collaterals	Discharge mRS score
1	65	7	Right	Pcomm, ophthalmic	2
2	55	5	Left	Pcomm, ophthalmic	2
3	55	4	Bilateral	Pcomm, ophthalmic	0

Pcomm = Posterior communicating artery.

Case Reports

Patient characteristics are summarized in table 1.

Case 1

A patient with a history of hypertension and hyperlipidemia presented after being found unresponsive. With stimulation, the patient became more alert but was noted to have a right gaze preference with left arm and leg drift as well as slurred speech [National Institutes of Health Stroke Scale (NIHSS) score of 7]. An MRI

Fig. 2. **a** An MRI of the head reveals an area of restricted diffusion in the left frontal lobe. **b** A sagittal projection reveals a left internal carotid occlusion. **c** An anteroposterior projection of the head after a contrast injection in the right vertebral artery reveals filling of the anterior circulation via the posterior communicating arteries. **d** An anteroposterior projection of the head and neck reveals good filling of the left hemisphere after left carotid stent placement.

of the head revealed a right frontal infarct, and a CT angiography (CTA) of the head/neck was concerning for bilateral ICA occlusions. He was placed on a heparin drip, and a catheter-based angiogram on post-stroke day 2 confirmed bilateral carotid occlusions (fig. 1a) as well as a right vertebral artery origin occlusion. A left vertebral artery injection revealed filling of both cerebral hemispheres through a diminutive posterior communicating artery as well as retrograde filling of the right ICA through the right ophthalmic artery.

Given the moderate-sized stroke burden, the patient was managed initially with anticoagulation. On post-stroke day 7, the patient underwent repeat catheter-based angiography revealing persistent occlusion of the left ICA. However, the right ICA was faintly patent with a trickle of flow (fig. 1b). The patient underwent successful right carotid stent placement with a post-stenting angiogram revealing good crossflow to the left hemisphere via the anterior communicating artery (fig. 1c, d). The hospital course was complicated by aspiration pneumonia. The patient was discharged to a rehabilitation center on hospital day 13 on aspirin and Plavix with an mRS score of 2. At 1-year follow-up, his NIHSS score was 1 and his mRS score was 1.

Case 2

A patient with a history of hyperlipidemia, hypertension and tobacco use presented with a transient episode of right-sided weakness. The patient was placed on aspirin and clopidogrel and discharged home. Three days later, the patient returned with persistent right arm weakness as well as with mild language difficulties with an NIHSS score of 5. The patient was transferred to our facility for further care. An MRI of the head revealed a left frontal and insular infarct (fig. 2a) with a CTA of the head/neck revealing bilateral ICA occlusions. A catheter-based angiogram confirmed bilateral ICA occlusions (fig. 2b) with filling of the bilateral hemispheres via the posterior communicating arteries (fig. 2c). The patient underwent successful carotid stent placement of the left ICA (fig. 2d) with good flow to the anterior circulation. The patient was discharged to a rehabilitation center on hospital day 5 on aspirin and clopidogrel with an mRS score of 2. At 1-year follow-up, his NIHSS score was 1 and his mRS score was 0.

Case 3

A patient with a history of coronary artery disease, hypertension, hyperlipidemia and tobacco use presented to an outside facility with a transient episode of slurred speech. A CT of the head revealed no acute

Fig. 3. **a** An MRI of the head reveals an area of subacute infarct in the right frontal lobe on T2-weighted imaging. **b** An axial CT of the head with contrast reveals prolonged mean transit times in both anterior circulation distributions on perfusion imaging. **c** A sagittal projection of the right ICA confirms an occlusion at the level of the bifurcation. **d** An anteroposterior projection of the head shows good flow distal to the occlusion with a microcatheter. **e** A sagittal projection of the right ICA reveals good flow after stent placement. **f** An anteroposterior projection of the head reveals good flow to the right hemisphere and right anterior cerebral artery after right ICA stent placement.

pathology. While undergoing evaluation of the carotid arteries with sonography, the patient became asystolic for 10 s. The patient briefly became unresponsive and upon arousal was noted to have left arm and leg weakness with a right gaze preference and slurred speech. The patient was transferred to our facility and, upon arrival, was noted to be drowsy but overall slightly improved with an NIHSS score of 5. An MRI of the head revealed a right frontal infarct (fig. 3a). A CTA of the head/neck was concerning for bilateral ICA occlusions. The patient was initially managed with permissive hypertension and anticoagulation. CT perfusion revealed prolonged mean transit times in both hemispheres (fig. 3b). On hospital day 1, the patient underwent catheter-based angiography confirming bilateral ICA occlusions (fig. 3c). The patient underwent successful right ICA stent placement with good filling of the right hemisphere and left anterior cerebral artery distribution. The left MCA distribution continued to rely on retrograde filling from the left ophthalmic artery. After the procedure, the patient remained drowsy with a repeat MRI of the head revealing a stable right frontal infarct and no new injury. The blood pressure was aggressively controlled to avoid cerebral hyperperfusion syndrome. A repeat CT perfusion scan revealed improved mean transit time to the right hemisphere, but the left hemisphere continued to have a prolonged mean transit time (fig. 4a). Given the persistent somnolence without underlying metabolic abnormalities, the occluded left ICA was stented (fig. 4b) with improved perfusion (fig. 4c) and flow (fig. 4d). The patient became more alert over the next 24 h and was discharged home on hospital day 7 with an NIHSS of 2 and an mRS score of 0. At 1-year follow-up, his NIHSS score was 0 and his mRS score was 0.

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Fig. 4. An axial CT of the head with contrast reveals prolonged mean transit times in the left hemisphere on perfusion imaging (**a**) which normalizes after left internal carotid stent placement (**b**). A sagittal projection of the left ICA confirms a persistent occlusion at the level of the bifurcation (**c**) with good flow to the left hemisphere after left ICA stent placement (**d**).

Discussion

Bilateral carotid occlusive disease is a rare but hemodynamically critical state as patients often rely on the posterior communicating artery or retrograde filling from the ophthalmic artery to maintain adequate perfusion [18]. The tenuous nature of these patients is highlighted by the fact that 2 of the 3 patients in this study presented with syncopal episodes (unwitnessed in case 1 and provoked in case 3), suggesting that these patients are susceptible to both focal symptoms and global hypoperfusion. In case 3, this was likely exacerbated by carotid sinus massage during the Doppler study. All 3 patients had clinical and radiographic evidence of stroke. In one series of 21 patients presenting with bilateral occlusions, 38% presented with a transient ischemic attack, 14% presented with amaurosis fugax, and 24% presented with strokes [6]. Two of the 3 patients in this study had recurrent events, and the third patient remained somnolent until both carotids were revascularized.

Patients presenting with symptoms often initially undergo noninvasive imaging with MRA or CTA. While these studies are highly sensitive, they can often misclassify high-grade stenosis as an occlusion (pseudo-occlusion) [19]. Since the management of carotid occlusion and high-grade stenosis may be different [4], a catheter-based study is essential in characterizing the true degree of stenosis and to further clarify the nature of collateral anastomosis. All 3 patients in this study demonstrated collateral flow through the posterior communicating and ophthalmic arteries, which likely accounts for the mildness of the presenting symptoms. Prior studies have demonstrated that an absent or hypoplastic posterior communicating

artery is associated with a higher risk of stroke in the setting of ICA occlusion [20]. Nonetheless, all 3 patients were judged to be at high risk for recurrent events based on their clinical history of recurrent symptoms or perfusion imaging demonstrating a significant perfusion deficit.

At present, there is little evidence to support management strategies for this disease. In the acute setting, induced hypertension and anticoagulation may be beneficial. In case 1, anticoagulation appeared to facilitate partial recanalization of the right internal carotid between day 2 and 7. Therefore, anticoagulation appears to be a reasonable therapy if patients are stable with small infarcts and a low risk of hemorrhagic transformation.

Surgical bypass or carotid endarterectomy may represent viable options for patients with bilateral carotid occlusions [21, 22]. In a series of 8 patients managed with medical therapy and of 13 patients managed with surgery, 8 underwent carotid endarterectomy, 4 carotid-subclavian bypass, and 1 underwent aorta-to-innominate artery bypass. Outcomes in the surgical group included 38% mortality and 15% recurrent events, as compared to 75% mortality and 75% recurrent events in the medical therapy group [6]. While surgery appears to be superior to medical therapy alone, the hemodynamic instability of this population may make general anesthesia and the associated risks of open microsurgery intolerable for a subset of these patients [23].

Conclusion

In this study, we demonstrate that carotid angioplasty and stenting may represent a safe and potential option for bilateral occlusive disease. Future studies are necessary to better understand the natural history of this disease and to define the optimal therapy for this high-risk population.

Disclosure Statement

T.G.J. has received consulting and speaker fees from Co-Axia, ev3, Concentric Medical and Micrus.

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