Carotid Stenting for Radiation-Induced Stenoses
A Report of 7 Cases
Emmanuel Houdart, MD; Charbel Mounayer, MD; René Chapot, MD; Jean-Pierre Saint-Maurice, MD; Jean-Jacques Merland, MD, PhD

Background and Purpose—Radiation-induced stenoses of the carotid artery are associated with fibrosis of the arterial layers and tissue planes that renders their surgical treatment difficult. We present our clinical experience in carotid angioplasty stenting (CAS) of patients harboring such stenoses.

Methods—Seven patients underwent transfemoral CAS of 10 radiation-induced stenoses located on either the common or the internal carotid artery. Six patients presented neurological symptoms. Four patients had undergone previous radical neck dissection, and 3 had permanent tracheostomies. Stenoses were primarily covered with a self-expandable stent before carotid dilation.

Results—All interventions were successful, with residual stenoses <20%. No permanent complication occurred. The mean follow-up was 8 months. Patients were symptom free at the last clinical examination, and Doppler control showed no evidence of restenosis.

Conclusions—Carotid stenting appears very attractive for such “hostile neck” patients and seems a safe and efficient treatment for radiation-induced stenoses. (Stroke. 2001;32:118-121.)

Key Words: angioplasty ■ carotid artery diseases ■ stenosis ■ stents

Extracranial carotid stenosis is a known complication of head and neck external irradiation. These stenoses are usually challenging for the vascular surgeon. Indeed, even when the stenosis is due to an atherosclerotic process, it is associated with fibrosis of both the arterial wall and normal tissue planes, which makes endarterectomy more difficult than for usual cases.1–3 In addition, many of these stenoses involve extensive segments of the carotid artery in the upper or lower part of the carotid bifurcation, which again renders their surgical approach more complicated. With the development of self-expandable stents, carotid angioplasty stenting (CAS) has become used more frequently.4,5 This technique avoids cervical dissection and therefore seems quite appropriate for these “hostile neck” patients. We review our experience with 7 patients who were treated by CAS over a 2-year period for 10 radiation-induced carotid artery stenoses.

Subjects and Method
Between April 1998 and April 2000, 7 patients with 10 radiation-induced stenoses of the carotid arteries underwent CAS. Since the beginning of this period, surgery had no longer been performed for that specific indication in our institution. All patients gave written informed consent for both the intervention and materials used.

Imaging Protocol
Before intervention, all patients underwent cerebral MRI or CT scan and 4-vessel angiography, including cervical and intracranial views. Stenoses were measured before and after CAS on radiographic films. Only patients with stenosis >70% according to North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria were treated. Intervention was judged successful when the residual stenosis was <20% on the control angiography. We termed internal carotid artery (ICA) stenosis a stenosis located either exclusively on the ICA or at the carotid bifurcation, and we termed common carotid artery (CCA) stenosis a stenosis located exclusively below the bifurcation. To measure the exact diameter of the arteries and length of the stenoses, angiography was performed after placement of a coin on the neck in a plane orthogonal to the radiographic view. It was possible to calculate the size of the structures studied when the diameter of the coin was known.

Clinical Protocol
A neurological examination by an experienced neurologist was performed on all the patients before the procedure, after the intervention, and before discharge. Clinical follow-up and a cervical Doppler were performed at 1 month and every 6 months after CAS for all patients.
Characteristics of Patients and Stenoses

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age/ySex</th>
<th>Interval*/Initial Malignancy</th>
<th>Previous Associated Treatment</th>
<th>Neurological Symptoms</th>
<th>Stented Arteries/Length of Stenosis, mm</th>
<th>Associated Arterial Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>79/M</td>
<td>12 y /laryngeal carcinoma</td>
<td>Cervical Surgery</td>
<td>TIA</td>
<td>L ICA /35</td>
<td>Thrombosis R ICA</td>
</tr>
<tr>
<td>2</td>
<td>53/M</td>
<td>6 y /lymphoma</td>
<td>...</td>
<td>TIA</td>
<td>R ICA /10 L ICA /40 R VA /5</td>
<td>Thrombosis L SCA</td>
</tr>
<tr>
<td>3</td>
<td>56/M</td>
<td>4 y /laryngeal carcinoma</td>
<td>...</td>
<td>TIA</td>
<td>L ICA /20</td>
<td>...</td>
</tr>
<tr>
<td>4</td>
<td>78/M</td>
<td>5 y /laryngeal carcinoma</td>
<td>Cervical surgery, tracheotomy</td>
<td>TIA</td>
<td>R CCA /30 L CCA /30 L ICA /20</td>
<td>...</td>
</tr>
<tr>
<td>5</td>
<td>59/M</td>
<td>15 y /laryngeal carcinoma</td>
<td>...</td>
<td>TIA</td>
<td>L ICA /40</td>
<td>Stenosis R ICA</td>
</tr>
<tr>
<td>6</td>
<td>63/M</td>
<td>4 y /pharyngeal carcinoma</td>
<td>Cervical surgery</td>
<td>Minor stroke</td>
<td>L ICA /6</td>
<td>...</td>
</tr>
<tr>
<td>7</td>
<td>60/M</td>
<td>10 y /laryngeal carcinoma</td>
<td>Cervical surgery, tracheotomy</td>
<td>None</td>
<td>L CCA /40</td>
<td>...</td>
</tr>
</tbody>
</table>

TIA indicates transient ischemic attack; L, left; R, right; VA, vertebral artery; and SCA, subclavian artery.

*Interval from irradiation to neurological symptoms.

Antithrombotic Protocol
Antiplatlet therapy, with clopidogrel 75 mg and aspirin 100 mg, was started 5 days before CAS and continued for 1 month after the procedure, after which clopidogrel was interrupted and the aspirin continued for life. During the intervention, 5000 U of intravenous heparin was given once the femoral sheath was in place. One patient had a poststenotic thrombus seen on initial angiography and received an intravenous perfusion of abciximab (ReoPro, Lilly Inc). This treatment resulted in disappearance of the thrombus, which allowed the CAS procedure to be performed.

Balloon Angioplasty and Stenting Protocol
The interventions were performed by the femoral approach. An 8F guiding catheter was placed in the CCA. Primary stenting was performed with the use of a self-expandable stent in all cases. We used an Easy Wallstent in the first 3 patients and a Carotid Wallstent (Schneider-Boston Scientific Inc) in the other patients. The diameter of the prosthesis was adapted to the largest diameter of the artery that needed to be covered. The stenosis was passed with a wire, and the stent was deployed to cover the entire length of the stenosis. A balloon angioplasty catheter was then introduced into the stent and inflated to a maximum pressure of 10 atm. Atropine 1 mg was given before balloon inflation. In 2 cases of ICA stenosis, we used a cerebral protection device (Guardwire, Percusurge Inc) during stent deployment and balloon dilation. Control angiography, including cervical and intracranial views, was systematically performed. The femoral sheath was removed on the same day after normalization of the activated clotting time. In case of bilateral carotid stenoses, CAS was performed sequentially at a 15-day interval. After angioplasty, the patients were systematically observed for 24 hours in the intensive care unit.

Results
Patient and Stenosis Characteristics
The clinical characteristics of the patients and stenoses are shown in the Table. Six of the 7 patients were symptomatic. Five patients had presented either a motor deficit or aphasia, and 1 had presented retinal symptoms. The mean interval between radiation therapy and neurological symptoms onset was 8 years (range, 4 to 15 years). Four patients had undergone previous cancer surgery on the same side as the carotid stenosis, and 2 of them had permanent tracheostomies. Six of the 10 stenoses had a length ≥30 mm. Three of the 10 stenoses affected the CCA exclusively. Two patients had stenoses on >2 major cerebral arteries.

Clinical and Angiographic Results
Nine interventions were performed. Two patients had bilateral carotid stenoses that were treated in separate sessions. Ten carotid arteries were stented: 7 ICA and 3 CCA. Additionally, in 1 patient a vertebral artery was stented during a CAS session. In the 2 stenoses treated under cerebral protection, analysis of the blood aspirated below the protection balloon revealed cholesterol debris.

Interventions were successful for all stenoses. There was no permanent complication. One transient complication occurred in the patient presenting occlusion of the opposite ICA. Inflation of the balloon angioplasty led to a partial motor seizure that resolved immediately after the deflation of the balloon.

The hospitalization duration was 3 days for all patients. The mean clinical and Doppler follow-up was 8 months (range, 3 to 24 months). All the patients were symptom free at the last clinical examination. All the stents were permeable on the last Doppler control.

Illustrative Case: Case 4
A 78-year-old right-handed man was seen in June 1999 after several episodes of visual flashes followed by blurred vision that occurred alternatively in both eyes. These symptoms occurred mainly during physical activity and were interpreted by our neurologist as transient bilateral retinal ischemia. The patient had undergone total laryngectomy with permanent tracheostomy followed by cervical irradiation for a laryngeal carcinoma in 1984. The neurological examination was nor-
Clinical examination found typical “hostile neck” signs. Cervical Doppler revealed tight stenoses of both carotid arteries. Transcranial Doppler showed decreased velocities in both middle cerebral arteries.

Angiography revealed a long, tight stenosis of the right CCA associated with a long stenosis of the left CCA and left ICA (Figure).

It was decided to perform sequential CAS of the right and left carotid arteries, beginning with the right CCA stenosis because this was the simplest lesion to treat. Indeed, the longest intervention was to be on the left side, and we wanted to improve the arterial blood flow to the brain through the right carotid artery before performing it. Follow-up after CAS of the right side was uneventful, and the patient was discharged on day 2. Treatment of the left carotid stenoses was undertaken 1 month later. Two stents were implanted, one at the CCA stenosis and the other at the ICA stenosis. The patient was discharged on day 2, neurologically intact. At 6-month follow-up, the visual symptoms had completely disappeared. The control cervical Doppler showed normal carotid diameters, and the transcranial Doppler showed normalization of the velocity in the middle cerebral artery.

Discussion

Three types of radiation damage to the carotid artery after neck irradiation have been described. Carotid rupture has been reported mainly when radiotherapy was associated with radical neck dissection. In the majority of the cases, the rupture occurred after a surgical complication such as postoperative necrosis of skin flaps, fistulas, or infection of the surgical wound. Early arterial occlusion, occurring within months after radiotherapy, is the second reported complication. The third and most frequent lesion is the late development of atherosclerosis in the arteries included in the radiation fields. This complication has been reported to occur more frequently in patients with nasopharyngeal or laryngeal carcinomas. Six of the 7 patients of our series had been treated for such carcinomas. In this type of lesion, neurological symptoms occur several years after irradiation. Although histology of the surgical specimens has shown atherosclerotic plaque with cholesterol crystals, angiographic findings differ from the nonirradiated cases. The stenoses are usually long and affect arteries infrequently involved by standard atherosclerosis, such as the CCA. The clinical and radiological findings in our series were concordant with those data.
Surgical treatment of such stenoses is more difficult than for usual cases. Indeed, cervical dissection is disturbed by the scar tissue caused by irradiation. These difficulties are further increased if the patient has undergone previous radical neck surgery on the same side because of the additional surgical scar. Such changes increase the risk of damage to the adjacent vessels or nerves. Endarterectomy of ICA stenoses is also more difficult because of vessel wall changes consisting of adhesion of the different layers, which complicates the removal of the plaque itself. When stenosis involves a proximal segment of CCA, the treatment sometimes requires a surgical bypass, implying a more aggressive dissection. In addition to the risks related to irradiation, some of these patients had undergone previous tracheostomy because of their initial malignancy, which carries an additional risk. Indeed, the proximity of the stoma to the operative field increases the risk of postoperative infection, especially if a synthetic material has been used for vascular reconstruction. There are few surgical reports of endarterectomy for radiation-induced stenoses. In a series of 10 patients, 1 postoperative stroke occurred, and 1 patient developed a pseudoaneurysm. Wound closure required dermal grafting in 2 other patients. In the largest series including 24 patients, 6 had postoperative cranial nerves palsies, and 4 required dermal grafting.

Because of the development of self-expandable stents, the number of patients treated by CAS is increasing rapidly. This technique has not been compared with endarterectomy and therefore cannot be proposed routinely for treatment of standard stenoses. However, for radiation-induced stenoses that have been excluded from the NASCET and European Carotid Surgery Trial studies, CAS is attractive for those patients with predictable difficulties in neck dissection. For CCA stenoses (whose surgical results have not been prospectively assessed), CAS seems much less invasive than surgical bypass. Since the development of self-expandable stents, radiation-induced stenoses have been treated exclusively by CAS at our institution. Indication for treatment was justified in 6 cases by neurological symptoms. In the asymptomatic patient, CAS was performed because of the tightness of the stenosis, which was associated with a decrease of velocity of the middle cerebral artery.

We applied our usual technique, which primarily involves covering of the stenosis with a self-expandable stent followed by its dilation. Balloons were not inflated to >10 atm because we were concerned about potential arterial rupture at higher pressure. Bilateral carotid stenoses were treated in sequential sessions. We established this policy to avoid ischemic complication in both hemispheres (with its catastrophic cognitive consequences), which could occur if the stenoses were treated at the same time.

We used a protective cerebral device in 2 cases of ICA stenoses when the device was available. Although the benefit of this technique has not been demonstrated, it is increasingly recommended to avoid possible embolic migration to the brain during CAS. Because radiation-induced stenoses are actually accelerated atherosclerosis, cerebral protection is justified to the same degree as for standard patients. No consensus exists in the literature for use of cerebral protection. Our policy is to use it when treating long stenoses because embolic migration seems more likely to occur in that situation.

With the exception of our series, only 1 article has been published regarding the use of CAS for radiation-induced stenoses. The reported results in those 14 patients are similar to ours.

Because of the prolonged survival of patients treated by radiation, the frequency of this long-term side effect is expected to increase. In a prospective study, late stenosis of carotid artery was depicted in 11.7% of 240 patients who underwent cervical irradiation. Some physicians are reluctant to consider surgical options for these high-surgical-risk patients. Accordingly, CAS is a potential alternative that seems both safe and effective. However, further studies with longer follow-up are required to confirm these initial results.

References
Carotid Stenting for Radiation-Induced Stenoses: A Report of 7 Cases
Emmanuel Houdart, Charbel Mounayer, René Chapot, Jean-Pierre Saint-Maurice and Jean-Jacques Merland

Stroke. 2001;32:118-121
doi: 10.1161/01.STR.32.1.118

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2001 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/32/1/118

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org//subscriptions/