Restenosis Predictors after Carotid Angioplasty and Stenting and Its Influence on Procedure Durability, Single-Center Experience

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Background: This article reports our experience regarding in-stent restenosis in the carotid arteries with special focus was given to angiographic morphology and clinical predictors of in-stent restenosis. *Methods:* Between July 2008 and August 2011, 245 carotid angioplasty and stenting procedures were performed in 243 patients (172 men and 71 women). Stenting for de novo stenoses was performed in 214 (87.3%) carotid arteries, and 31 (12.7%) vessels were treated because of post-surgical restenosis. Symptomatic lesions were detected in 187 patients (76.3%). Angiography confirmed any significant recurrent lesion detected on the ultrasound scan. Symptomatic or significant (70%) recurrent lesions detected on the ultrasound scan were an indication for retreatment. *Results:* During the follow-up period of 821 days (range: 62-1750 days), there were 10 deaths, all non–procedure related. Stent restenosis was defined as greater than 30% narrowing of the vessel lumen diameter and could be detected in 35 (14.3%) patients. Retreatment was indicated in 16 (6.5%) patients. Three types of restenosis were differentiated: tandem type restenosis (n = 5 of 35); "in-stent" restenosis (n = 18 of 35); and "end-stent" restenosis (n = 12 of 35). Interventions, either dilation alone (n = 12) or dilation with restenting (n = 4) for restenosis, were performed with 1 procedure-related dysphasia that resolved in 30 days. Female gender, hypercholesterolemia, peripheral vascular disease (PVD), initial stenosis, and surgical graft were predictors of target lesion revascularization. *Conclusions:* In our cohort, history of surgical end-arterectomy, female gender, hypercholesterolemia, PVD, and initial stenosis were predictors of in-stent restenosis. Three types of restenosis were identified in our cohort. **Key Words:** Carotid—restenosis—CAS—CEA—predictors.

Introduction

One of the prevalent concerns about the carotid angioplasty and stenting (CAS) procedure is the development of restenosis, which limits the long-term effectiveness of the procedure. In-stent restenosis after CAS has been reported to occur in 4%-6% of cases.[1-3] Several prospective randomized multicenter studies have shown that surgery for high-grade internal carotid artery (ICA) stenosis reduces the incidence of stroke and death.[4,5] However, recurrent stenosis is not uncommon after surgery and has been reported in 3%-36% of cases.[6] In the growing population of patients who have been treated with carotid stent placement, the incidence of recurrent lesions appears to be rather low in single-center experience.[7-9] A global

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series of 5210 carotid stents in 4757 patients reported a recurrence rate of only 1.99% after 6 months and 3.46% after 12 months.[10] However, little is known about the morphology of recurrent stenosis after carotid stenting, and management strategies have not been reported systematically.[1,11,12]

The aim of this study was to identify the incidence of stenosis recurrence after CAS, and to identify possible predictors of in-stent restenosis and possible impact on the outcomes.

Materials and Methods

A retrospective study was conducted on patients undergoing CAS for significant de novo or recurrent carotid artery occlusive disease between July 2008 and August 2011. Clinical, laboratory, diagnostic, and operative reports, as well as the hospital and postoperative course of each patient, were stored in a computerized database. Examination of the database identified 243 patients (172 men; median age 69 years, interquartile range [IQR] 62-84) who underwent CAS. The etiology of the 245 lesions (2 bilateral treated in staged procedures) was de novo stenosis in 214 (87.3.0%) and postsurgical restenosis in 31 (12.7%). About three-fourths of the patients (n = 187, 76.3%) were symptomatic. Stroke was the presenting symptoms before CAS in 45.7% of the cases.

In brief, our carotid stenting protocol was approved by the local Ethics Committee. Eligibility was based on an angiographically determined stenosis of ≥70% according to the North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria.[13]

Carotid Stent Protocol

A neurologist examined all patients before each procedure to ascertain neurological function; brain scans, computed tomography (CT) or magnetic resonance imaging, were performed in all cases. Patients treated electively received clopidogrel (75 mg/d) plus aspirin (325 mg/d) for at least 3 days before the intervention. Patients who were not premedicated received a loading dose of clopidogrel (300 mg) before the intervention. Details of our carotid stenting protocol was published before,[14] where all procedures were performed without a cerebral protection device. A femoral approach was used in all cases except in 1 (difficult anatomy), where direct carotid approach was performed. The severity of stenosis was measured according to the NASCET criteria.[15] A total of 221 (90.2%) patients had single stent placement for their stenosis, deployment of 2 stents was encountered in 19 lesions (7.8%), and 3 stents were deployed in 5 lesions (2%). Nitinol stents were deployed in 109 lesions (44.7%). Tapered stents were used in 84 lesions (34.3%). Predilation with a 2- or 2.5-mm angioplasty balloon was inevitable to introduce stent in 52 (21.2%), in all of these patients in whom the stenosis (tight stenosis) or severe calcifications could not be passed with the stent delivery system. After stenting, control angiogram of the treated carotid artery took place. Where postdilation was performed when homogenous stent deployment failed (residual stenosis was considered when more than 25%) or failure of reconstitution of acceptable intracranial perfusion). Postdilation was performed in 239 lesions in our series. Finally, a cervical and cerebral angiogram was obtained to control the final results. Within 24 hours after CAS, the same neurologist examined each patient. Any neurological change was recorded. The antiplatelet regimen was continued after stent implantation according to the Stent-Protected Angioplasty versus Carotid Endarterectomy study protocol.[16]

Follow-Up Protocol and Criteria of Restenosis Assessment

All patients were followed at the hospital's outpatient clinic at 1, 3, 6, 9, and 12 months after the procedure, and every 6 months thereafter. During these routine postoperative visits, a neurologist examined each patient, and exact information about clinical adverse events in between was asked about, and a carotid duplex scan was obtained. If any change in neurological status was found, either a brain CT scan or a magnetic resonance image was obtained. The diagnosis and quantification of restenosis was performed noninvasively using color-coded duplex ultrasonography. In the majority of cases, an intracranial Doppler flow study was also performed. The modified Zwiebel classification[17] was used to grade degrees of ICA stenosis; restenoses were classified as mild (>30%-50%), moderate (>50%-79%), or severe (>79%). The choice among the carotid artery imaging methods depends mainly on the clinical indications for imaging and the availability and expertise at individual centers. To improve the accuracy of the diagnosis, the use of 2 imaging modalities before revascularization is suggested. Like in our cohort, we used ultrasound as screening tool, whereas digital subtraction angiography was the confirmatory test for revascularization.

Statistical Analysis

All patients were traced for the common closing date of August 1, 2014. Data sets were analyzed using univariate methods, with the goal of determining the risk factors correlated with the development of restenosis. Variables that were believed to have an impact on recurrent stenosis in the carotid arteries included age, sex, smoking, chronic obstructive pulmonary disease, hypertension, diabetes mellitus, hypercholesterolemia (>200 mg/mL), peripheral arterial disease, ischemic heart diseases, chronic heart failure, aortic arch atherosclerosis, in-stent restenosis in other vascular districts, baseline percent stenosis, lesion length, baseline vessel diameter, vessel diameter after stenting, lesion location (proximal or distal ICA), symptomatic stenosis, side of carotid lesion, postsurgical carotid