Extracranial Carotid Artery Stenting: The Puerto Rico Medical Center Endovascular Neurosurgery Service Experience

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Objective: Extracranial carotid artery stenting (CAS) represents a viable alternative for high-risk surgical patients. The aim of this study was to determine the clinical features and outcome of 25 patients that underwent CAS at the Puerto Rico Medical Center.

Methods: A retrospective review of a series of 25 high-risk surgical patients that underwent CAS from June 2005 to January 2010 was performed. Patients were followed-up at clinics with computed tomography angiography and/or digital subtraction angiography.

Results: Patient ages ranged from 52 to 88 years. Twenty-one of the patients had severe cervical carotid stenosis (more than 80%). Those with moderate stenosis (from 50% to 80%) were treated when they were symptomatic or when stenosis recurred after carotid endarterectomy. Among the 25 patients, only 2 presented with restenosis (more than 50% luminal diameter). Both had a history of radiation-induced disease, but neither required retreatment. Five patients required post-stenting angioplasty due to a less than 50% improvement in luminal diameter. There was 1 death, and 1 patient presented delayed neurocognitive deterioration. The combined long-term morbidity and mortality in the subgroup with at least two years of follow-up was 8.3%. There were no intracerebral hemorrhages or recurrent strokes/transient ischemic attacks.

Conclusion: The restriction of post-stenting angioplasty to only those cases without significant revascularization appears to help reduce restenosis rates while ensuring a gradual increase in intracranial blood flow. The latter may not apply to patients with a prior history of radiotherapy. [*P R Health Sci J 2011;30:69-72*]

Key words: Extracranial carotid stenting, Angioplasty, Outcome, Puerto Rico

Worldwide, stroke is the third leading cause of death and the most associated with permanent disability (1). While primary prevention comprises our first line of defense against atherosclerosis, by reducing its incidence and prevalence, once the disease is established we can only prevent its complications. Secondary prevention strategies and alternatives have expanded in the last decades. Current alternatives include combined medical management with antiplatelet and cholesterol-reducing agent regimes, carotid endarterectomy (CEA), and carotid artery angioplasty and stenting (CAS).

CAS represents a viable alternative for high-risk surgical patients. Several studies have shown better clinical results from CAS in this setting than in those instances in which CEA was used, especially in the hands of an expert interventionist (1-2). Nevertheless, much remains to be learned about indications, patient selection, and technical improvements, both in the current treatment population and in those patients for whom surgical risk is low to moderate. It is possible that this last category of patients may derive equal benefit from either CEA or CAS, perhaps even receiving a greater level of benefit from the latter of the two procedures. In August 2004, the Food and Drug Administration (FDA) approved the first CAS system for symptomatic stenosis (from 50 to 80%) and for asymptomatic stenosis greater than 80% (2). In the United States, Medicare coverage was approved in March 2005, but only for symptomatic lesions of more than 70%, and after the evaluation of the patient by a vascular surgeon (2). Currently CEA is preferred for carotid stenosis in low- to moderate-risk surgical patients, while CAS is reserved for high-risk surgical patients. Herein, we report the clinical features and outcomes of 25 patients that underwent CAS at the Puerto Rico Medical Center.

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Methods

We retrospectively reviewed a series of 25 high-risk surgical patients that underwent 26 extracranial carotid stent placements between June 2005 and January 2010. Institutional Review Committee approval was granted before the review of the medical records. The selection criteria for the study population are shown in Table 1. Trauma-associated lesions were excluded. In the majority of cases, patients were referred by vascular surgeons.

Table 1. High surgical-risk selection criteria for the patient population.

Criteria	N
Restenosis after endarterectomy	3
Radiation-induced stenosis*	2
Contralateral stenosis	4
High bifurcation/difficult anatomy	11
Chronic obstructive pulmonary disease	2
Coronary artery disease/Congestive heart failure	7

*Radiation for neck cancer

Patients were premedicated with aspirin (325 mg orally daily) and Plavix® (Bristol-Myers Squibb, New York, NY) (75 mg orally daily) for at least 3 days prior to the procedure (if not already taking it). Oral antihypertensives, when already being used by a given patient, were continued on the day of the procedure. Procedures were carried out after thorough case evaluations, including anesthesiology and cardiology (as needed), and using standardized institutional- and Occupational Safety and Health Administration (OSHA)-approved occupational safety measures as well as utilizing aseptic materials and techniques. Patients were treated under conscious sedation, with oxygen supplementation as well as with cardiac and respiratory monitoring. Sedative and analgesic agents included midazolam (0.07-0.08 mg/kg per dose, IV) and fentanyl (1-2 mcg/kg per dose, IV) (3). Digital subtraction angiography (DSA) was done with a biplane digital subtraction angiography unit with 3-D reconstruction (Allura, Philips, Andover, MA). Catheterization, angioplasty, and stenting materials included the Shuttle Select™ System (Cook Medical, Bloomington, IN) placed over a Vtk Slip-Cath® (Cook Medical, Bloomington, IN). Distal embolic protection devices (DEPD) included the Filter Wire EZ (Boston Scientific, Natick, MA), Emboshield (Abbott Vascular, Abbott Park, IL), and Angioguard (Cordis, Bridgewater, NJ). Dilation balloon catheters ranging from 2.5 mm to 6 mm nominal diameter were also used as needed for angioplasty of the diseased segment of the vessel. Carotid stents included the X-act Carotid Stent (Abbott Vascular, Abbott Park, IL), Next Stent (Boston Scientific, Natick, MA), and Precise® (Cordis, Bridgewater, NJ). Stent diameter and length, whether open or closed-cell configuration, tapered or non-tapered, were chosen based on the angiographic characteristics of the diseased carotid segment.

Clinical and radiographic follow-up was done at our clinics and/or by phone interview, and with computed tomography angiography (CTA) and/or digital subtraction angiography (DSA) in selected cases, respectively.

Results

Over the course of 4.6 years, a total of 26 stents were placed successfully in 25 patients. One patient who suffered from tandem lesions in the cervical carotid required 2 stents in series. Ages ranged from 52 to 88 years (mean, 67.7 years). Sex was evenly distributed, for a male-to-female ratio of 13:12. Twenty-one patients had severe cervical carotid stenosis (more than 80%); 9 of those were symptomatic. Of those with moderate (between 50 to 80%) stenosis (4 patients), 2 were treated when symptomatic, and 2 were treated when, after CEA, the stenosis was found to be recurrent and there was evidence of progression.

The mean follow-up was 22.2 months (range, 3-52 months). The follow-up was distributed as follows: 2 patients were monitored for more than 4 years, 2 were monitored for 3 to 4 years, 7 for 2 to 3 years, 7 for 1 to 2 years, 3 for 6 months to 1 year, and 4 were evaluated within 6 months of the procedure. The mean length of time to the first angiographic follow-up was 18.2 months (range 2-52 months). Five patients (20%) did not receive their scheduled angiographic follow-up. Of those 5, 2 received no follow-up at all due to poor compliance. The angiographic follow-ups were distributed as follows: 1 patient was monitored for more than 4 years, none were monitored for 3 to 4 years, 6 were monitored for 2 to 3 years, 7 for 1 to 2 years, 5 for 6 months to 1 year, and 4 were evaluated within 6 months of the procedure.

Five patients required post-stenting angioplasty because revascularization produced only marginal improvement in luminal diameter (less than 50%). The rest attained a 50% or greater improvement in diameter after the initial angioplasty and stenting. Two patients presented with restenosis (the distal luminal diameter having narrowed to less than 50%). Both had histories of radiation-induced disease. One of these patients had undergone post-dilation during the initial procedure and remained without evidence of restenosis for at least 26 months; the other presented restenosis in less than 7 months. The overall restenosis rate was 8%. No retreatment was necessary since these patients did not present associated symptoms and stenoses were non-progressive, ranging from 60 to 65%.

Clinical and functional outcomes were evaluated and graded using the modified Rankin Disability Scale (mRDS) (4). At 2 years the majority of patients remained stable; 1 showed a delayed marginal improvement of 1 point (mRDS), another

showed a marginal worsening of 1 point (mRDS), and 2 presented significant long-term clinical deterioration not likely related to the procedure. Of these last 2 patients, 1 died suddenly 5 months after the procedure for unknown reasons. The other presented severe cognitive and psychomotor deterioration due to vascular dementia progression 2 years after CAS. Follow-up brain MRI and DSA confirmed that the changes were not due to restenosis. Combined long-term morbidity and mortality in the subgroup with at least 2 years of follow-up was 8%. There were no incidences of intracranial bleedings, recurrent strokes, or transient ischemic attacks.

Discussion

In the last decades the debate arguing the merits of surgical vs. endovascular management of cervical carotid atherosclerotic disease has led to the delineation of certain guidelines accepted by most institutions. Endarterectomy is usually reserved for low- to moderate-risk surgical patients with significant carotid stenosis, usually more than 50% stenosis when symptomatic and more than 70% when asymptomatic (more than 80% when asymptomatic for CAS as approved by the FDA) (1, 2, 9, 11). Endovascular management is primarily reserved for high-risk surgical patients that may still benefit from revascularization procedures when the best combined medical management of their stenosis remains insufficient. High-risk patients have significant medical conditions, such as congestive heart failure, recent myocardial infarction, and chronic obstructive pulmonary disease, among others (1, 9, 11). Also, high-risk patients include those who present difficult anatomies for surgical interventions (such as very high or very low carotid bifurcations) or that have other important risk factors such as having had a prior surgery in the affected area, having a history of neck radiation, having an infection, or having had a tracheostomy, among others (1, 9, 11).

Table 2 shows a favorable comparison between the early and the late outcomes of our series and those of other series reported in the literature. Although our sample is small, techniques such as the use of distal embolic protection devices (DEPD), premedication with antiplatelet agents, anticoagulation, close blood pressure monitoring during and after the procedure, and avoidance of any unnecessary post-stenting angioplasties may have helped reduce complications. In terms of angiographic outcome (Table 3), the overall restenosis rates are comparable to those reported, except in radiation-induced cases, where our rate approached 100% at 26 months. In these cases, though there were only 2, a tendency was noted toward longer duration with post-stenting angioplasty. Restenosis was noted at 6 months in the case that did not undergo post-dilation. Nevertheless, none of these patients required retreatment and still continue under observation. This raises important questions about the need for post-dilation in radiation-induced stenosis and regarding whether performance is of any clinical significance in the long run, despite evidence of some recurrence. Of note, the 5 patients requiring post-stenting angioplasty (20%) had critical carotid stenosis of more than 85%, including 1 patient with radiation-induced stenosis. Nevertheless 15 other patients (60%) in the series also had similar critical stenoses but did not require post-stenting angioplasty. Hence, the difference between these two subgroups in terms of the immediate angiographic outcomes may lie in the compliance of the plaques. Detailed information about the physical characteristics of the plaques was not collected, and although CT angiography revealed calcification in the majority of cases, it may be worthwhile to gather these data from MRI and/or sonographic studies.

Table 2. Comparison of morbidity and mortality rates between our series and others in the literature.*

Other series	Puerto Rico Medical Center series
CaRESS (6, 7): 2.1% at 30 days mortality: 0% ELOCAS (8): 4.1% at 1 year SAPPHIRE (9): 25.5% at 3 years Kastrup et al (10): 1.7% at 30 days Ecker et al (2): 3.3% at 30 days Tang et al (11): 4.2% at 30 days	Combined 30-day morbidity/ Combined long-term (2-year) morbidity/mortality: 8.0%

*Combined major adverse events (including stroke and death)

Since the sample of CAS patients being treated is small at present, significant statistical and clinical extrapolations are difficult to come by. In certain cases in which restenosis is very likely (e.g., radiation-induced cases), a trend that may favor post-dilation has been noted. Such a trend may aid in the design of other studies directed at improving the outcomes of CAS procedures. In the near future, these refinements can expand CAS applications and solidify the role of the procedure as a primary alternative in the treatment of low- to moderate-risk surgical patients suffering from cervical carotid stenosis.

Our results corroborate prior findings that CAS can be a safe and effective alternative for high-risk surgical patients requiring extracranial carotid revascularization. The restriction of post-stenting angioplasty or post-dilation to those cases in our series that did not experience significant improvement to blood flow (resulting from revascularization) after angioplasty and stenting (that is, a luminal diameter improvement of less than 50%), suggests that it (CAS) can help reduce restenosis rates, while ensuring a gradual increase in intracranial blood flow. The latter may not apply to patients with prior history of radiotherapy. Further analyses with a larger number of patients may provide further detail on specific indications for angioplasty during CAS, especially in this diverse population of patients.

Table 3. Comparison of early and late restenosis rates between our series and others in the literature.

Other series	Puerto Rico Medical Center series
SAPPHIRE (9): 20% at 1 year	Overall restenosis rate at 6 months: 4.0%; at 3 years: 8.0%.
Lanzino et al (5): 5.5 % in CEA restenosis series	Restenosis rates in radiotherapy patients at 6 months: 50%; at 3 years: 100%.
Shawl (12): 2.7% at 2 years Ting et al (13): 17.6% at 2.5 years in radiation-induced stenosis series Gray et al (14): 3.1% at 6 months Lal et al (15): 9.3% at 18.8 months Chakhtoura et al[16] 8% at 18 months Cohen et al (17): 0% at 16 months in radiation-induced stenosis series and 20% at 92 months in CEA restenosis series (with post-dilation).	

Resumen

Objetivo: El stent carotídeo extracraneal representa una alternativa viable para los pacientes de alto riesgo quirúrgico. El objetivo de estudio fue determinar las características clínicas y resultados de 25 pacientes que fueron tratados con stenting carotídeo extracraneal en el Centro Médico de Puerto Rico. Métodos: Se realizó un estudio retrospectivo en 25 pacientes tratados con stenting carotídeo extracraneal desde junio de 2005 a enero de 2010. El seguimiento se dio en clínicas y con angiotomografía computarizada y/o angiografía con substracción digital. Resultados: Las edades fluctuaron entre 52 y 88 años. La mayoría (21 pacientes) tenía estenosis crítica carotídea (mayor de 80%). Aquellos con estenosis moderada (de 50% a 80%) eran sintomáticos o presentaron recurrencia luego de endarterectomía. De los 25 pacientes sólo dos presentaron reestenosis (más de 50% del diámetro luminal). Ambos tenían enfermedad inducida por radiación, pero ninguno requirió tratamiento adicional. Cinco pacientes requirieron angioplastia post-stent debido a pobre mejoría (menos de 50% del diámetro luminal). Un paciente murió y otro presentó deterioro neurocognitivo tardío. La morbilidad y mortalidad a largo plazo en aquellos con seguimiento de al menos dos años fue de 8.3%. No hubo sangrados intracraneales o ataques isquémicos recurrentes. Conclusión: El limitar la angioplastía post-stent a sólo aquellos casos con pobre revascularización (menos de 50% en nuestra serie), aparentemente disminuye la incidencia de reestenosis, y promueve un aumento gradual en el flujo cerebral. Esto último, no necesariamente aplica a pacientes con enfermedad relacionada a radiación.

References

1. Bilkoo P, Mukherjee D. Percutaneous versus surgical revascularization for symptomatic carotid artery disease. Curr Cardiol Rep 2009;11:384-90.
2. Ecker RD, Lau T, Levy EI, et al. Thirty-day morbidity and mortality rates for carotid artery intervention by surgeons who perform both carotid endarterectomy and carotid artery angioplasty and stent placement. J Neurosurg 2007;106:217-21.
3. Barash PG, Cullen BF, Stoelting RK, et al. Handbook of Clinical Anesthesia. 6th ed. Philadelphia, PA: Wolters Kluwer Health/Lippinkott Williams & Wilkins; 2009:1093-1110.
4. Rankin J. Cerebral vascular accidents in patients over the age of 60. II: Prognosis. Scott Med J 1957; 2:200-15.
5. Lanzino G, Mericle RA, Lopes DK, et al. Percutaneous transluminal angioplasty and stent placement for recurrent carotid artery stenosis. J Neurosurg 1999; 90:688-94.
6. CARESS Steering Committee. Carotid revascularization using endarterectomy or stenting systems (CARESS): phase I clinical trial. J Endovasc Ther 2003; 10:1021-30.
7. CaRESS Steering Committee. Carotid Revascularization Using Endarterectomy or Stenting Systems (CaRESS) phase I clinical trial: 1-year results. J Vasc Surg 2005;42:213-9.
8. Bosiers M, Peeters P, Deloose K, et al. Does carotid artery stenting work on the long run: 5-year results in high-volume centers (ELOCAS Registry). J Cardiovasc Surg (Torino) 2005; 46:241-7.
9. Yadav JS, Wholey MH, Kuntz RE, et al. Protected carotid-artery stenting versus endarterectomy in high-risk patients. N Engl J Med 2004;351: 1493-501.
10. Kastrup A, Gröschel K, Schulz JB, et al. Clinical predictors of transient ischemic attack, stroke, or death within 30 days of carotid angioplasty and stenting. Stroke 2005; 36:787-91.
11. Tang GL, Matsumura JS, Morasch MD, et al. Carotid angioplasty and stenting vs carotid endarterectomy for treatment of asymptomatic disease: single-center experience. Arch Surg 2008; 143(7):653-8.
12. Shawl FA. Carotid artery stenting: acute and long-term results. Curr Opin Cardiol 2002; 17:671-6.
13. Ting AC, Cheng SW, Yeung KM, et al. Carotid stenting for radiation-induced extracranial carotid artery occlusive disease: efficacy and midterm outcomes. J Endovasc Ther 2004; 11:53-9.
14. Gray WA, White HJ Jr, Barrett DM, et al. Carotid stenting and endarterectomy: a clinical and cost comparison of revascularization strategies. Stroke 2002;33:1063-70.
15. Lal BK, Hobson RW 2nd, Goldstein J, et al. In-stent recurrent stenosis after carotid artery stenting: life table analysis and clinical relevance. J Vasc Surg 2003;38:1162-8.
16. Chakhtoura EY, Hobson RW 2nd, Goldstein J, et al. In-stent restenosis after carotid angioplasty-stenting: incidence and management. J Vasc Surg 2001;33:220-5.
17. Cohen JE , Rajz G , Lylyk P, et al. Protected stent-assisted angioplasty in radiation-induced carotid artery stenosis. Neurol Res 2005; 27 Suppl 1:S69-72.