

Carotid Artery Stenting in High Risk Patients with Carotid Artery Stenosis Not Eligible for Endarterectomy: Clinical Outcome after 5 Years

Itzhak Kimiagar MD¹, Colin Klein MD¹, Jose M. Rabey MD¹, Amir Peer MD², Edo Kaluski MD³, Michael Zaretsky⁴ and Arie Bass MD⁴

¹Department of Neurology, ²Interventional Radiology Unit, ³Institute of Cardiology and ⁴Department of Vascular Surgery, Assaf Harofeh Medical Center, Zerifin, and Sackler Faculty of Medicine, Tel Aviv University, Ramat Aviv, Israel

Key words: stents, stenosis, stroke, carotid, high risk patients

Abstract

Background: Carotid artery stenting is used as an alternative to surgical endarterectomy.

Objectives: To determine the outcome of CAS in a retrospective cohort of patients.

Methods: Between July 1999 and March 2003, 56 consecutive patients with carotid artery stenosis who were considered ineligible for surgery were treated (45 males, 11 females, mean age 69). All underwent the procedure prior to the introduction of distal protective devices in Israel.

Results: Intraprocedural complications included transient neurological findings in 5 patients (8%), cerebrovascular accident in 2 (3%), hemodynamic changes in 11 (18%), and 4 procedural failures. Post-procedural complications included transient ischemic attack in 3 patients and cardiovascular accident in 6 (10%). At 30 days follow-up, three patients (5%) remained with signs of CVA. Two patients (3%) died during the post-procedural period and 16 (28%) during the 5 year follow-up, one due to recurrent CVA and the remainder to non-neurological causes. Five-year carotid Doppler follow-up was performed in 25 patients (45%), which revealed normal stent flow in 21 (84%), 50–60% restenosis in 3 (12%) and > 70% restenosis in one patient (4%).

Conclusions: This study confirms that stent procedures are beneficial for symptomatic carotid stenosis in patients not eligible for surgery.

IMAJ 2008;10:121–124

Approximately 600,000 people suffer a stroke each year in the United States. This results in nearly 160,000 deaths and leaves many more with major disability [1]. Carotid endarterectomy has been shown to be superior to medical treatment in reducing the overall risk of stroke in symptomatic or asymptomatic patients with significant carotid artery stenosis [2,3]. Although endarterectomy is considered to be the gold standard treatment for carotid artery stenosis, the approach is not free of complications. In the North American Symptomatic Carotid Endarterectomy Trial study population, 5.8% of the patients suffered from perioperative stroke and death, and it was also reported that subgroups of patients at high risk had mortality and morbidity rates of up to 18% [2,4]. Carotid angioplasty and stenting are being used as an alternative

treatment for extracranial carotid disease [5-7]. The feasibility and relative safety of percutaneous transfemoral extracranial carotid stenting has been reported in high risk patients [8].

Carotid stenting may avoid some of the perioperative complications of CEA. The National Institutes of Health/National Institute of Neurological Disorders and Stroke approved funding for the Carotid Revascularization Endarterectomy Versus Stent Trial, a multicenter randomized trial, to compare these two techniques [9]. Reports suggest that carotid stenting can be performed with an acceptable 30 day complication rate [6,7,10-14].

Patients and Methods

Patient population

Between July 1999 and March 2003, 56 consecutive patients (45 male, 11 female) underwent carotid artery stenting at Assaf Harofeh Medical Center, a community hospital serving a population of approximately 500,000. Four of these patients were treated by bilateral CAS resulting in 60 procedures.

Patients were eligible for CAS if they had symptomatic carotid artery disease and severe ($\geq 70\%$ diameter) stenosis of the carotid artery – according to the measurement criteria of NASCET by Doppler and by angiography [15]; these measurements would be equivalent to 75% stenosis according to the European Carotid Surgery Trial measurement [16] – combined with either a high medical risk: unfavorable anatomy (a short or excessively long neck with a high bifurcation), hostile neck (this being a neck with fibrosis as a result of previous surgery or trauma), post-radiation carotid stenosis, or restenosis post-CEA.

A neurologist evaluated the neurological status of all the patients during the workup period, 1 day before, and weekly after the procedure during the first month. Patients with previous cerebrovascular accident, transient ischemic attack or infarcts were considered symptomatic. Cerebral computed tomography was performed in all patients.

All patients were on antiplatelet treatment of aspirin (mean dose 200 mg/day), ticlopidine (250 mg twice a day), or clopidogrel

CAS = carotid artery stenting
CVA = cardiovascular accident

CEA = carotid endarterectomy
NASCET = The North American Symptomatic Carotid Endarterectomy Trial

(75 mg/day). Aspirin with ticlopidine or clopidogrel was continued for at least one month after the stent was implanted.

Patients were excluded if they had a major neurological deficit or any other illness impeding informed consent, severe renal insufficiency (serum creatinine > 3.0 mg/dl), peripheral vascular disease precluding femoral artery access, or the presence of severe disability due to previous stroke or dementia. Patient selection was determined by a multidisciplinary stroke team including a cardiologist, a radiologist, a neurologist and vascular surgeons.

Procedure

Carotid stenting was performed from the femoral approach. A long 7 FR Super Arrow-Flex Sheath (Arrow International, Reading, PA, USA) was advanced into the common carotid artery. Pre-dilatation with a low profile Savvy balloon catheter 4–20 mm (Cordis Europa, Roden, The Netherlands) was performed after administration of 0.6 mg atropine. The stent, either a WALLSTENT® (Boston Scientific Corporation, Rockland, MA) or a Smart Precise® (Cordis Corporation, Miami, FL) was deployed, from the internal to the common carotid. All stents used were 8–40 mm.

Secondary percutaneous transluminal angioplasty of the stent was performed, again after a bolus of 0.6 mg atropine, with a 6–40 mm balloon catheter. Post-stenting angiography was performed via the sheath of both the extra- and intracranial carotid artery. All patients had an indwelling temporary pacemaker and all received 4000 units of heparin during the procedure. Neuro and vascular monitoring was continuously performed during the whole procedure [17]. Post-procedure, the patients were transferred to the intensive coronary care unit for observation.

Results

Patient demographic data are summarized in Table 1. Intraprocedural complications (n=60) included transient neurological findings in 5 patients (8%) (confusion in 2, loss of consciousness in 2, related to hemodynamic changes, and transient hemiparesis in 1), all clearing within minutes; CVA in 2 patients (3%); and hemodynamic changes in 11 patients (18%) [Table 2].

There were four procedural failures (6%). Of these, one patient underwent urgent endarterectomy, one a vein graft, one a carotid ligation and one patient had spontaneous intraprocedural occlusion that was asymptomatic. Post-procedural complications [Table 3] (within the first 30 days following CAS) included TIA in three patients, two of which were vertebrobasilar, and CVA in six patients; four were major strokes with hemiplegia and two were minor CVA with mild hemiparesis. Hemorrhagic transformation was found in three patients. Of the eight CVA (two procedural and six post-procedural), seven were ipsilateral to the CAS and one was contralateral. On follow-up at 30 days, five patients had improved completely, two had improved partially and one remained unchanged. Thus at 30 days, three patients remained with signs of CVA (5%). Two patients (3%) died during the post-procedural period. One patient died 7 days after the procedure

TIA = transient ischemic attack

Table 1. Baseline characteristics of patients* (n=56)

	n	%
Gender		
Male	45	80
Female	11	20
Coronary heart disease (AP, CABG, MI, PTCA)	43	77
Hypertension	43	77
Diabetes mellitus	28	50
Hyperlipidemia	28	50
Current smoker or past history of smoking	18	32
History of stroke/TIA/amaurosis fugax	35	62
Bilateral carotid disease	48	86
Contralateral occlusion	9	16
Prior ipsilateral CEA, restenosis	11	20
Prior neck surgery or radiation therapy	8	14
Chronic lung disease	16	29
Syncope, vertigo	9	16
Renal failure	9	16
Peripheral vascular disease	22	39
Cardiac arrhythmia (PAF, CAF, SVT)	13	23

CEA = carotid endarterectomy, TIA = transient ischemic attack, AP = angina pectoris, MI = myocardial infarction, CABG = coronary artery bypass grafting, PTCA = percutaneous transluminal coronary angioplasty, PAF = paroxysmal atrial fibrillation, CAF = chronic atrial fibrillation, SVT = supraventricular tachycardia.

Table 2. Procedural complications – 60 procedures

Complication	n	%
TIA	1	1.6
CVA	2	3.3
Failed procedure	4	6.6
Bradycardia	3	5.0
Hypotension	4	6.6
Hypertension	2	3.3
Asymptomatic ECG changes	2	3.3
Transient confusion	2	3.3
Transient loss of consciousness	2	3.3

Table 3. Post-procedural complications (30 days) – 60 procedures

Complication	n	%
TIA carotid ipsilateral to procedure	1	1.6
Vertebrobasilar	2	3.3
CVA		
Ipsilateral to procedure	5	8.3
Contralateral to procedure	1	1.6
Transient confusion	2	3.3
Stent thrombosis	2	3.3
Myocardial infarct	1	1.6
Death	2	3.3

Table 4. Five-year follow-up: deaths (n=18)

Timing	No.	Non-	
		Neurological	neurological
Periprocedural	0	0	0
Post-procedural	2	0	2
1–12 months	3	0	3
13–24 months	2	0	2
25–36 months	4	0	4
37–48 months	4	1	3
49–60 months	3	0	3

due to cellulitis, septicemia and septic shock, and the second patient died 3 days after the procedure due to pulmonary edema and cardiac arrest. Eighteen patients died during the 5-year follow up, one due to CVA and 17 to non-neurological causes [Table 4]. Five-year carotid Doppler follow-up was performed in 25 patients (28 stent insertions). Normal stent flow was found in 21 patients, restenosis of 50–60% in 3 patients and restenosis of > 70% in one patient.

Discussion

We report our hospital's 5 year retrospective analysis of 56 patients (60 procedures) who underwent CAS. Patients referred for stenting constituted a high risk group and were considered not to be candidates for CEA. All cases reported here underwent the procedure prior to the introduction of distal protective devices in Israel. During the same period, 300 open carotid endarterectomies were performed. For the purpose of this study, patients were assessed by an independent neurologist from the hospital's stroke unit. This was considered to be essential in view of the report by Rothwell and co-authors [18] who reviewed 16,000 endarterectomies from 51 studies over 15 years and found a mean stroke and death rate of 5.6%. This varied from 2.3% in studies with a single author affiliated to the department of surgery, to 7.7% in studies where patients were assessed by a neurologist.

Our 30 day results are comparable to other studies: minor strokes in 2 patients (3%) and a major stroke in 1 patient (1.6%). Two patients (3%) died during the post-procedural period. Thus our 30 day major stroke/death rate was 4.6%. These results were similar to our results of open surgery. McKeivitt et al. [19] reported a 4.0% 30 day total major stroke and death rate in 150 stent patients without protective devices. Roubin and colleagues [20] reported a 7.4% overall 30 day stroke and death rate. Becquemin et al. [21] reported a combined permanent stroke/death rate of 2.6% in 107 stent patients (114 lesions) and an overall neurological event rate (including TIA) of 10.5%. In the high risk group undergoing stenting reported by Mathur et al. [22], the overall incidence of procedural stroke and death was 7.7% whereas in the NASCET-eligible subgroup of patients (low risk group) the risk of any stroke or death was 2.7%. In high risk patients undergoing endarterectomy, morbidity and mortality rates as high as 18% have been reported [22].

The study by Halabi et al. [23], a prospective single center study, evaluated CAS with and without distal protection devices

in high risk patients. Distal protection devices were used in 44% of their 126 procedures. The study comprised two subgroups: those with restenosis after prior CEA (63%) and those with *de novo* lesions. Thirty-one percent were considered by cardiologists to be ineligible for CEA, and 9% by surgeons because of hostile neck. In the group of restenosis after CEA, the death/stroke rate was 4.5% and the overall rate of in-hospital major adverse cerebrovascular events was 2.6% (death, stroke or myocardial infarction). In the *de novo* group with distal protection devices, the death/stroke rate was 0%. Minor embolic events were not completely prevented by distal protection.

The study by Yadav et al. [24] compared CAS and CEA in 334 patients with coexisting conditions that potentially increased the risk of CEA, and found that CAS with emboli protection devices was not inferior to CEA. In the periprocedural period (30 days), the cumulative incidence of stroke, myocardial infarction or death was 4.8% in patients assigned to receive a stent and 9.8% among those assigned CEA. We had a high rate of transient neurological events in the intra- and immediate post-procedural period: 9 patients (15%) including TIA or reversible ischemic neurological deficit compared to 10.5% in the Becquemin study [21] and 13% in the Qureschi study [14]. Qureschi found symptomatic lesions, the length of the stenotic lesion (≥ 11.2 mm), and the absence of hypercholesterolemia to be the three variables associated with periprocedural deficits, whereas Mathur and team [22] claimed that advanced age and long or multiple stenoses were independent predictors of procedural stroke. These periprocedural complications can be expected to decrease following the introduction of distal protective devices, as was reported in the updated review of the Global Carotid Artery Stent Registry [25]. In that review, the overall complications rates during the placement or within 30 days were TIA 3.07%, minor strokes 2.14%, major strokes 1.2%, and procedure-related deaths 0.4%. The combined minor and major stroke and procedure-related death rate was 3.98% as compared to 5.29% stroke and procedure-related death rate in procedures performed without protection devices.

In summary, it is our opinion that stent procedures are beneficial for symptomatic carotid stenosis in high risk patients and we recommend that patients be assessed and managed by a multidisciplinary team.

References

1. American Heart Association. Heart and Stroke Statistical Update. Dallas, Texas: American Heart Association, 2000.
2. Barnett HJ, Taylor DW, Eliasziw M, et al. Benefit of carotid endarterectomy in patients with symptomatic moderate or severe stenosis. North American Symptomatic Carotid Endarterectomy Trial Collaborators. *N Engl J Med* 1998;339:1415–25.
3. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. *JAMA* 1995;273:1421–8.
4. MCR European Carotid Surgery Trial Investigators. Randomised trial of endarterectomy for recently symptomatic carotid stenosis: final results of the MRC European Carotid Surgery Trial (ECST). *Lancet* 1998;351:1379–87.
5. Bergeron P, Chambran P, Hartung O, Bianca S. Cervical carotid

- artery stenosis: which technique, balloon angioplasty or surgery? *J Cardiovasc Surg (Torino)* 1996;37(Suppl 1):73–5.
6. Theron JG, Payelle GG, Coskun O, Huet HF, Guimaraens L. Carotid artery stenosis: treatment with protected balloon angioplasty and stent placement. *Radiology* 1996;201:627–36.
 7. Yadav JS, Roubin GS, Iyer S, et al. Elective stenting of the extracranial carotid arteries. *Circulation* 1997;95:376–81.
 8. Laird JR, Satler LF, Popma JJ, et al. Procedural results and early clinical outcomes after carotid stent-supported angioplasty in high-risk patients [Abstract]. *J Am Coll Cardiol* 1997;29:362A.
 9. Hobson RW 2nd, Brott T, Ferguson R, et al. CREST: carotid revascularization endarterectomy versus stent trial. *Cardiovasc Surg* 1997;5:457–8.
 10. Bergeron P, Becquemin JP, Jausseran et al. Percutaneous stenting of the internal carotid artery: the European CAST I Study. Carotid Artery Stent Trial. *Ann Clin Psychiatry* 1999;11:141–4.
 11. Diethrich EB, Ndiaye M, Reid DB. Stenting in the carotid artery: initial experience in 110 patients. *J Endovasc Surg* 1996;3:42–62.
 12. Henry M, Amor M, Masson I, et al. Angioplasty and stenting of the extracranial carotid arteries. *J Endovasc Surg* 1998;5:293–304.
 13. Mathias K, Jager H, Sahl H, Hennigs S, Gissler HM. Interventional treatment of arteriosclerotic carotid stenosis. *Radiologe* 1999;39:125–34.
 14. Qureshi AI, Luft AR, Janardhan V, et al. Identification of patients at risk for periprocedural neurological deficits associated with carotid angioplasty and stenting. *Stroke* 2000;31:376–82.
 15. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med* 1991;325:445–53.
 16. Albers GW, Hart RG, Lutsep HL, Newell DW, Sacco RL. AHA Scientific Statement. Supplement to the guidelines for the management of transient ischemic attacks: A statement from the Ad Hoc Committee on Guidelines for the Management of Transient Ischemic Attacks, Stroke Council, American Heart Association. *Stroke* 1999;30:2502–11.
 17. Gomez CR, Roubin GS, Dean LS, et al. Neurological monitoring during carotid artery stenting: the Duck Squeezing Test. *J Endovasc Surg* 1999;6:332–6.
 18. Rothwell PM, Slattery H, Warlow CP. A systematic review of the risks of stroke and death due to endarterectomy for symptomatic carotid stenosis. *Stroke* 1996;27:260–5.
 19. McKeivitt FM, Macdonald S, Venables GS, Cleveland TJ, Gaines PA. Complications following carotid angioplasty and carotid stenting in patients with symptomatic carotid artery disease. *Cerebrovasc Disc* 2004;17:28–34.
 20. Roubin GS, New G, Iyer SS, et al. Immediate and late clinical outcomes of carotid artery stenting in patients with symptomatic and asymptomatic carotid artery stenosis: a 5-year prospective analysis. *Circulation* 2001;103:532–7.
 21. Becquemin JP, Ben El Kadi H, Desgranges P, Kobeiter H. Carotid stenting versus carotid surgery: a prospective cohort study. *J Endovasc Ther* 2003;10:687–94.
 22. Mathur A, Roubin GS, Iyer SS, et al. Predictors of stroke complicating carotid artery stenting. *Circulation* 1998;97:1239–45.
 23. Halabi M, Gruberg L, Pitchersky D, et al. Carotid artery stenting in surgical high-risk patients. *Catheter Cardiovasc Interv* 2006;67:512–18.
 24. 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.
 25. Wholey MH, Al-Mubarek N, Wholey MGH. Updated review of the global carotid artery stent registry. *Catheter Cardiovasc Interv* 2003;60:259–66.
-
- Correspondence:** Dr. I. Kimiagar, Dept. of Neurology, Assaf Harofeh Medical Center, Zerifin 70300, Israel.
Phone: (972-8) 977-9180
Fax: (972-8) 977-9182
email: fredricag@asaf.health.gov.il