Angioplasty with Stenting in Treatment of Carotid Artery Stenosis: report of a 3-year series

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Carotid angioplasty with stent placement has been proposed as an alternative treatment for revascularization of carotid artery stenosis. In this article, we describe our series of stent-assisted carotid angioplasty and summarize the safety and feasibility of this procedure.

We performed 38 cervical carotid bifurcation angioplasty with stents in 35 patients during November 1999 to December 2002. The carotid bifurcation stenosis was induced by atherosclerotic plaque in 33 cases and post-radiation stenosis in 2 cases. The inclusion criteria for stenting was diameter stenosis >70% in any patients or stenosis >50% in symptomatic patients.

Diagnostic cerebral angiography was performed before every procedures. Percutaneous transluminal angioplasty and stenting were performed with the goal of final diameter stenosis <30%. Any event occurring during procedure and within 3 days after procedure was recorded as procedure-relative. New neurological deficits or death occurred during follow-up was documented as late event.

The mean pre-treatment diameter stenosis was 74.0% and final residual diameter stenosis 9.1%. The rate of peri-procedural morbidity was 5.3%. No peri-procedural death was noted. One patient suffered from ipsilateral minor stroke and another suffered from acute myocardial infarction. Five late ipsilateral or bilateral ischemic strokes (14.3%) occurred in mean 15.9 months’ follow-up. The restenosis rate was 11.4%.

It is safe and feasible to treat carotid stenotic patient using stent-assisted angioplasty.

Key words: Carotid stenosis; Ischemic stroke; Stent

The most common disabling disorder occurring in the middle-aged and elderly population is cerebrovascular ischemic accident. Stenosis of extracranial carotid artery is a well-known cause of ischemic stroke. In Taiwan, the incidence of carotid stenosis in patients with cortical infarction was reported to be 32% [1]. Carotid endarterectomy was variably applied in patients with significant extracranial carotid artery stenosis for more than 40 years. North American Symptomatic Carotid Endarterectomy Trial (NASCET) confirmed the effectiveness of carotid endarterectomy in symptomatic patients and the Asymptomatic Carotid Atherosclerotic Study (ACAS) demonstrated its utility in the asymptomatic patients. These two landmark trials firmly established carotid endarterectomy as the standard therapy for carotid bifurcation disease [2-3]. The initial result from the NASCET reported in August 1991 demonstrated a highly beneficial effect of carotid endarterectomy in patients with angiographically confirmed high-grade carotid stenosis (70% to 99%) [2]. The final results for patients with stenosis <70% revealed modest benefit from carotid endarterectomy in selected patients with moderate degrees of stenosis (50% to 69%) [4]. However, several subsequent surveys of carotid endarterectomy have confirmed that rates of stroke and death are higher than reported in these trials [5-6].

Percutaneous endovascular techniques have been
studied for many years for their appealing potential as a safer, less traumatic alternative especially in patients with high surgical risk. Although it is still an emerging technique using evolving equipment, several single center reports and worldwide surveys of carotid stenting have demonstrated procedural results approaching those of endarterectomy [7-9]. We report our series of consecutive endovascular carotid interventions. The patients are described in terms of technical evolution, results, complications and long-term follow-up.

**MATERIAL AND METHODS**

**Patient Selection**

In the period of 37 months (from November 1999 to December 2002), 38 cervical carotid bifurcation stenotic lesions in 35 patients were treated by percutaneous transluminal angioplasty (PTA) and stenting (34 cases) or stenting alone (2 cases). Twenty-nine patients were male and there were six females. The mean age was 69 years old (range 40-86). The carotid bifurcation stenosis was due to atherosclerotic plaque in 36 cases and to post-radiation stenosis in 2 cases. The patients with history of ipsilateral ischemic stroke or transient neurological deficit were classified as symptomatic. The inclusion criteria for stenting was diameter stenosis >70% in every lesions or stenosis >50% in symptomatic lesions. The exclusion criteria were: cerebral infarction within 2 weeks, cerebral hemorrhage within 6 months, dementia status, major operation within 3 months, bleeding tendency, any intracranial vascular anomaly such as AVM or aneurysm and known allergy to aspirin or ticlopidine. Brain MRI, CT or neck Doppler ultrasound was available for all patients.

**Clinical Protocol**

Complete neurological examination before and 24 hours after the procedure were performed by neurologists. Any event occurring during stenting procedure and within 3 days after procedure was recorded as procedure-relative. New neurological deficits or death occurred during follow-up were documented as follow-up results. Patients received regular neurologists’ clinical visits for follow-up. Post-stenting medications included: ticlopidine (250mg oral twice daily) or clopedigrol (75mg oral daily) for 2 months and aspirin (100 or 324mg oral daily) throughout life time. Neck Doppler ultrasound study was performed soon after the procedure and then every 3 months. When restenosis was suspected, repeated angiography was performed to confirm recurrence.

**Technique**

Patients received ticlopidine (250mg oral twice daily) or clopedigrol (75mg oral daily), aspirin (100 or 324mg oral daily) and fraxiparin (0.6ml subcutaneous per 12 hours) for at least 72 hours before the procedure. Diagnostic cerebral angiography was...
performed several days before stenting and always include epiaortic trunks from their origins and four-vessel study of intracranial circulation. Diameter stenosis was calculated using NASCET criteria [10]. The lesion length was also measured.

During the procedure intravenous heparin was administered for anticoagulation. Blood pressure, EKG and oxygen saturation were monitored. Atropine (1 mg intravenous) was administered once bradycardia attacks after balloon dilatation or stenting of the stenosis.

Pre-dilatation of the stenosis was done if the lesion was too stenotic to pass the stent. Self-expanding stents (Easy Wall stent, Boston Scientific Schneider, Bülach, Switzerland; or SMART stent, Cordis, Miami, FL., USA) were used. The stents were placed in the ICA or cross the bifurcation, covering the whole plaque and not only the stenotic segment. Post-dilatation was selectively performed with the goal of final diameter stenosis <30%. Figure 1 shows the typical procedural results.

**RESULTS**

**Patients’ Baseline and Angiographic Characteristics**

Patients’ baseline and angiographic characteristics were shown in Table 1. The mean age was 69 ± 7.8 years. Second time stenting was performed in two patients due to in-stent restenosis. Bilateral carotid stenting was performed in one patient. Seven patients (20.0%) suffered from non-specific neurological symptoms such as vertigo and dizziness, 7 patients (20.0%) suffered from transient neurological deficits and 21 patients (60.0%) had minor stroke.

**Procedure Results**

Table 2 summarized the procedure characteristics. 38 cervical carotid angioplasty with stenting were performed with a total of 41 self-expanding stents (39 Easy Wall and 2 SMART) deployed in 36 target vessels (bilateral carotid stenting was performed in one patient). Pre-dilatation was done in 50.0% of the lesions and post-dilatation in 94.7% of the lesions. The mean diameter stenosis is 74 ± 10% before treatment and 9.1 ± 9.9% after treatment.

**Procedure-relative Complication**

Procedure-relative complications were summarized in Table 3. No patient suffered from intracerebral hemorrhage (ICH), neither contralateral stroke nor death. One patient suffered from ipsilateral minor stroke two days after stenting and recovered within two days. Another patient suffered from congestive heart failure due to acute myocardial infarction (AMI) one day after stenting and received coronary artery bypass graft. Minor cardiovascular effects (hypotension, tachycardia or bradycardia) were noted in 7
(18.4%) patients. All of their blood pressure returned stable within two days after medical control. Two patients complained about headache.

**Follow-Up Results**

The follow-up results were listed in Table 4. The mean follow-up time was 15.9 (range 1-37) months. Scheduled ultrasound study was performed every 3 months. Repeated angiography was arranged to confirm restenosis in patients with symptoms. There were 4 (11.4%) in-stent restenosis (restenosis diameter >70%), three of them were symptomatic and one was asymptomatic. The mean diameter stenosis of the in-stent restenosis was 82.8 ± 9.8%. One patient suffered from 80% restenosis below the stent and the other 67.8% distal to the stent. Recurrent stroke from target vessel territory was noted in 5 patients (14.3%). Three (8.6%) are ipsilateral and the other two (5.7%) were bilateral. No neurological death occurred during follow-up but one patient died for head injury and another for lung cancer.

**DISCUSSION**

Stenting for carotid stenosis has emerged as a potential alternative to endarterectomy, especially in

<table>
<thead>
<tr>
<th>No. of treated patients reaching interval</th>
<th>&lt; 1wk</th>
<th>1wk ~ 1mo</th>
<th>1mo ~ 1yr</th>
<th>1yr ~ 2yrs</th>
<th>&gt; 2 yrs</th>
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<td>Clinical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Death (non-neurologic)</td>
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<tr>
<td>Cerebrovascular disease</td>
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<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
</tr>
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<td>Head injury</td>
<td>1(2.9%)</td>
<td></td>
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<tr>
<td>Lung cancer</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(5.7%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>Ipsilateral stroke</td>
<td>0(0%)</td>
<td>2(5.7%)</td>
<td>1(2.9%)</td>
<td>0(0%)</td>
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<tr>
<td>Contralateral stroke</td>
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<td>0(0%)</td>
<td>2(5.7%)</td>
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<td>0(0%)</td>
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<tr>
<td>Angiographic</td>
<td></td>
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<tr>
<td>Restenosis &gt;70% diameter stenosis</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(2.9%)</td>
<td>3(8.6%)</td>
<td>0(0%)</td>
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**Figure 2.** Angiography of a 69-year-old man with high grade in-stent restenosis. **a.** Initial angiography showed 70% stenosis on left proximal internal carotid artery and the stenotic carotid artery was extremely tortuous. **b.** An Easy Wallstent was deployed with residual stenosis about 30%. **c.** 18 months later, the patient suffered from recurrent ipsilateral ischemic stroke. Repeated angiography showed high grade in-stent restenosis of left internal carotid artery.
patients of contralateral carotid occlusion, post-endarterectomy restenosis, radiation-induced stenosis and surgical inaccessible lesions. Beside, it has no risk of cranial nerve damage and could have less cost and resource utilization [8].

In this study, we demonstrated our initial result of the carotid stenting procedure. The 5.3% peri-procedural morbidity rate is similar to previous reports [7-9]. However, the rate of in-stent restenosis within two years is obviously higher in our study (11.4 %) than in other published reports (0-3.46%) [7-9]. In our experience, the patients with hypertension history and pretreatment stenosis rate >70% had a higher risk of early restenosis. Another possible cause of early restenosis was target vessel’s tortuosity, as demonstrated in Figure 2. In management of extremely tortuous vessels, nintinol stents should be adopted instead of stainless stents since they have better flexibility to suit the target vessels.

Five patients (14.3%) suffered from recurrent stroke after carotid stenting. Two of them had >70% in-stent restenosis and other 3 suffered from multiple intracranial and extracranial atherosclerotic narrowing. These may contribute to ischemic stroke later on.

The potential improvement in endovascular equipment and technique remains immense [11]. Those potential areas of innovation include dedicated carotid stent designs that taper in diameter distally to accommodate size discrepancy between common carotid artery and internal carotid artery; protection by using intravascular filters or balloons; smaller, more flexible and less traumatic delivery systems; lowering rate of restenosis secondary to intimal hyperplasia by using drug-coating stent and improving adjuvant pharmacologic regimen.

CONCLUSION

Stenting for carotid artery stenosis is a safe and effective treatment. The technical success rate and procedure-related morbidity/mortality rate compared close to those of carotid endarterectomy. With improvement of endovascular equipment, technique and adjuvant pharmacologic therapy, stent-assistant carotid angioplasty could play a more active role in stroke prevention.

REFERENCES

頸動脈血管支架對頸動脈狹窄的治療

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本文章收集三十五位接受頸動脈支架放置及血管成型術之病例。收集時間由1999年11月到2002年12月間，目的是探討頸動脈支架及血管成型術之安全及可行性。

三十五位病人中，三十三位的頸動脈狹窄起因於動脈粥狀硬化，其餘兩位乃因過去曾接受頸部放射療法。本治療的適應症為頸動脈口徑狹窄大於70%或是大於50%且有症狀。

治療前平均的頸動脈管徑狹窄為74%，治療後則是9.1%。治療中或治療後一個月內相關併發症的發生率是5.3%。在平均15.9個月的追蹤治療中，有14.3%的病人發生同側或雙側的復發性中風。

頸動脈支架及血管成型術應用於治療頸動脈狹窄病患，成為外科手術外的另一選擇。

關鍵詞：頸動脈狹窄，缺血性中風，血管支架