HOSPITAL CHRONICLES 2008, 3(3): 136–140

ORIGINAL ARTICLE

Subclavian and Vertebral Artery Angioplasty - Vertebro-basilar Insufficiency: Clinical Aspects and Diagnosis

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ABSTRACT

BACKGROUND: Percutaneous transluminal angioplasty (PTA) for significant stenosis involving the origin of the vertebral artery is now a well established treatment for selected patients when posterior cerebral arterial circulation is compromised. We demonstrate from our short and long-term results, after transluminal treatment of subclavian and vertebral artery stenosis, the feasibility and safety of treatment with balloon angioplasty and stenting.

PATIENTS AND METHODS: A total of 181 patients underwent endovascular treatment and were divided into two groups. In group A, we treated patients with chronic vertebrobasilar insufficient. In this group, 21 patients with severe vertebral artery stenosis had also concomitant severe stenosis in other supra aortic arteries. In group B we treated patients with subclavian steal syndrome. In this group 21 patients presented with coexistence of severe stenosis in other supra aortic arteries. Stent patency of subclavian and vertebral artery during follow up was assessed by duplex scan and physical examination, with comparison of brachial blood pressure of both arms especially in patients with subclavian stenosis. Digital angiography was performed in available patients. Cerebral oximetry and intracranial Doppler were used to determine the group of patients that we had to treat with balloon angioplasty and stenting.

RESULTS: Successful stenting was achieved in all cases. There were no complications. The primary stenting patency during follow-up (mean 8.6 months) was 98.6%. With use of intracranial Doppler we found 31 patients with higher blood flow in the basilar artery after stenting and 24 patients were found with increased brain regional oxygen saturation in the anterior cerebral artery.

CONCLUSION: Endovascular treatment of subclavian and vertebral arteries with balloon angioplasty and stenting was found to be necessary in certain cases and a less invasive alternative to surgical repair. Long-term results must still be confirmed in further studies.

KEY WORDS: *percutaneous transluminal angioplasty; stroke; subclavian steal syndrome; angiography*

LIST OF ABBREVIATIONS:
CT = computed tomography
PTA = percutaneous transluminal angioplasty
MRA = magnetic resonance angiography
rSO2 = regional oxygen saturation

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Presented in part at "**Cardiology Update 2004**", International Cardiology Symposium of Evagelismos General Hospital of Athens, Athens, Greece, October 14-16, 2004

INTRODUCTION

The back of the brain contains structures which are crucial for sustaining life. For instance, the brainstem controls respiration, swallowing, and the level of consciousness. Other structures of the back of the brain are the occipital lobes (the vision areas of the brain) and the cerebellum (which controls motor coordination). Obstructive lesions of the vertebral arteries may cause symptoms of vertebrobasilar insufficiency. When there is severe stenosis or occlusion in the subclavian artery, the phenomenon of subclavian steal syndrome occurs, which usually causes also symptoms from the vertebrobasilar territory because blood supply to the arm is provided by the ipsilateral vertebral artery. Although these are often ignored, symptomatic atherosclerotic stenoses involving this circulation will often respond to balloon angioplasty or primary stenting with real potential benefits to the patient in terms of symptom resolution.

We herein present our single-center experience with balloon angioplasty and stenting of the subclavian and vertebral arteries, evaluating simultaneously the brain regional oxygen saturation (rSO_2) changes during the vertebral artery occlusion period. We also studied the basilar artery runoff changes before and after vertebral and subclavian artery angioplasty, to further evaluate the efficacy of the procedure and to identify patients in whom subclavian and vertebral artery angioplasty should be applied.

PATIENTS AND METHODS

From September 2000 to February 2004, 181 patients (159 men and 22 women; mean age 63.8 years) underwent angioplasty and stenting of the subclavian and vertebral arteries. These patients were divided in to two groups. In *group A*, we studied 52 patients with chronic vertebrobasilar insufficient suffering from severe vertebral artery stenosis. Eleven of these patients presented with coexistence of ipsilateral severe internal carotid artery stenosis, with contralateral (6 patients) and bilateral internal carotid artery stenosis (4 patients). Eleven patients in group A presented with hypoplastic contralateral vertebral artery. In *group B*, we studied 129 patients with symptomatic severe subclavian artery stenosis. Twelve of these patients had also bilateral internal carotid artery stenosis, while 6 patients had contralateral internal carotid stenosis and 3 patients had ipsilateral carotid stenosis.

All patients underwent pre-interventional neurological evaluation, Duplex scan, and brain computed tomography (CT) scan. Aortic arch angiography and four-vessel digital angiography were performed to evaluate extra- and intra-cranial arteries. Special attention was paid to the subclavian and vertebral arteries and to the collateral blood flow to posterior cerebral circulation.

Vertebral artery stenosis was considered to be angiographically significant when greater than 70%. The angiographic appearance of the atherosclerotic vertebral lesions in this series was uniform, showing smooth luminal stenosis without plaque ulceration at the origin of the vessel. There was no evidence of distal vertebral or basilar artery stenosis in any patient. Endovascular approach was performed via a transfemoral route with use of local anesthesia. After arterial puncture, a 7F sheath was inserted and systemic anticoagulation was achieved with heparin (5000 IU). A 7F guiding catheter was then navigated into the subclavian artery. The narrowed arterial segment was then crossed with a 160-cm-long 0.014-inch guidewire that was navigated into the normal distal cervical vertebral artery. The PTA balloon catheter with the stent, was then placed over the guidewire and directed across the lesion site. The balloon was inflated up to the maximum recommended pressure to deploy and impact the stent into the inner arterial wall. Balloon inflation never lasted longer than 20 seconds.

The vertebral arteries in our patients had diameters of 4 to 5 mm. In all cases we used coronary stents from Boston Scientific Corp. In both groups during the procedure there was continuous monitoring of blood pressure, ECG and oxygen saturation. A 3100 SD Soma sensor was placed in the patients frontoparietal region, left and right and then it was connected with a cerebral oximeter 3100 INVOS R. For both groups the rSO_2 levels were recorded: a) Before femoral puncture and sheath insertion b) during guide catheter insertion in the vertebral artery origin and c) during balloon inflation and/or stent placement (occlusion period) (Table 1).

Immediately after stent placement, angiography was performed to assess the treated vessel. Careful attention was also paid to the intracranial circulation to exclude any sign of distal embolization. Patients were discharged from the hospital 24 hours after the procedure. They received 75 mg of ticlopidine and aspirin 100 mg daily for at least one year after stenting. Stent patency of subclavian and vertebral arteries during follow up was assessed by duplex scan and physical examination; particluarly in the patients with subclavian stenosis, this was also done with comparison of brachial blood pressure on both arms in all patients. Digital angiography was performed in available patients.

All patients of group A (43 male and 8 female patients) underwent vertebral angioplasty and stenting using balloon-expandable coronary stents (Fig. 1). All lesions were located at the origin of the vertebral artery (10 right, 42 left). Our population had a wide variety of symptoms of posterior fossa and posterior cerebral ischemia. Symptoms were refractory to medical therapy, including antiplatelet and anticoagulant medication, in all patients. Table 2 summarizes the patients' clinical data.

In group B, we treated 129 symptomatic patients with severe subclavian artery stenosis (Fig. 2). 12 of these patients had also bilateral internal carotid artery stenosis, with con-

TABLE 1

TABLE 2. Group A

No of Cases	Referring symptoms	Angiographic findings
5 patients	History of drop-attacks, vertigo	Severe stenosis of the left VA in 5 patients & 3 of these patients with severe LICA stenosis
11 patients	History of vertigo, nausea & dizziness	Severe stenosis of the left VA origin in 8 patients & of the right VA in 3 patients; 6 pts with severe LICA stenosis
34 patients	History of dizziness, vertigo	Severe stenosis of the left VA origin in 27 patients & right VA in 7 patients. 2 patients with bilateral severe stenosis, 2 patients with severe LICA stenosis & 6 patients with contralateral stenosis
2 patients	Several episodes of drop-attacks followed by right hemiparesis, left arm paresis, right facial numbness & dysarthria	Severe stenosis of the left VA origin & bilateral severe internal carotid artery stenosis in all pts.

VA = vertebral artery; LICA = left internal carotid artery

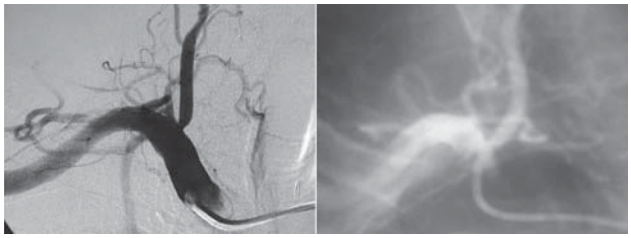

FIGURE 1. Vertebral angioplasty and stenting in a 66-year-old symptomatic patient (Catheterization & Interventional Lab, General Hospital of Nikaea, Piraeus).

tralateral internal carotid stenosis in 6 patients and ipsilateral internal carotid stenosis in 3 patients (Table 3).

RESULTS

Successful stenting was achieved in all cases (subclavian & vertebral arteries). There were no complications. The primary stenting patency during follow-up (mean 8.6 months) was 98.6%. A total of 31 patients presented with post stenting increased blood flow in the basilar artery and 24 patients

TABLE 3. Group B

No of Cases	Referring symptoms	Angiographic findings
72 patients	History of left arm claudication, dizziness & vertigo.	Severe stenosis of the left SA in 69 patients & of the right SA in 3 patients. Bilateral severe ICA stenosis in 10 patients, contralateral ICA stenosis in3 patients & ipsilateral ICA stenosis in 3 patients
39 patients	History of left arm claudication, dizziness & vertigo.	Severe stenosis of the left SA in 33 patients & of the right SA in 6 patients. With bilateral severe ICA stenosis in 2 patients
18 patients	History of arm claudication, Dizziness, vertigo.	Severe stenosis of the left SA in 12 & of the right SA in 3 patients. Contralateral ICA stenosis in 3 pts

SA = subclavian artery; ICA = internal carotid artery

GROUP B

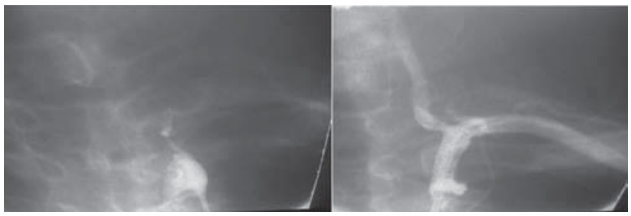

FIGURE 2. Subclavian angioplasty and stenting in a 55-year-old symptomatic patient (Catheterization & Interventional Lab, General Hospital of Nikaea, Piraeus).

were found with increased brain rSO_2 in the anterior cerebral artery.

Symptoms resolved in all patients after endovascular treatment. In no case was the residual stenosis greater than 20% nor were there any signs of distal embolization on the immediate control angiograms. No transient or permanent neurological deficits occurred.

DISCUSSION

The coexistence of supra-aortic atherosclerotic vascular disease is related to high incidence of myocardial infarction, stroke and mortality. Study and endovascular treatment of this disease is a great challenge for the cardiologist. Endovascular management of supra-aortic atherosclerotic vascular disease is becoming relatively common in the innominate, subclavian, and carotid arteries. However, revascularization of vertebral artery disease is an infrequently used treatment option due to several reasons: 1) stroke etiology and prevention generally considered with respect to carotid disease as posterior circulation ischemia is poorly defined; 2) the limited success and excessive morbidity have made surgery an unattractive option for vertebral artery revascularization; 3) routine screening for posterior circulation disease as an etiology for stroke is rarely performed; and 4) endovascular treatment of vertebrobasilar insufficiency is not routinely performed in peripheral interventional programs.

Randomized data comparing medical therapy, endovascular treatment, or surgical treatment do not exist.[1,2] Also we know that the majority of patients with symptoms of posterior cerebral circulation ischemia can be managed with conservative treatment, including anticoagulation and antiplatelet medication.[3] Most patients tolerate occlusion of one vertebral artery because there is usually sufficient blood perfusion from the contralateral side. For patients presenting with bilateral vertebral stenosis who are refractory to medical treatment, PTA is a viable alternative to surgery. Stents are used in order to improve blood flow to the posterior cerebral circulation and to reduce the risk of distal embolization.[4]

Ultrasound is the most common test for diagnosis of ischemia in the posterior circulation (vertebrobasilar insufficiency). MRI angiography (MRA) or DC angiogram are very useful to estimate the whole supra-aortic and brain arterial branch situation. CT scan and an electrocardiogram (ECG) and/or Holter monitoring to look for arrhytmias are also necessary before taking any therapeutic action.

Prognosis depends in part on the underlying cause. Strokes of the brainstem region are potentially life-threatening and demand urgent medical care. The most important prognostic factors are age and associated medical problems. When patients are young and have no significant medical problems, a substantial recovery can be expected. Recovery also depends upon the area of the brain that has been affected. The prognosis is very poor when the patient is in coma or cannot move both arms and legs. The complications of stroke are respiratory failure (which may require use of mechanical respiration), lung problems (especially respiratory infections), myocardial infarction, dehydration and swallowing problems. Problems with movement and/or sensation include paralysis, and numbness and the formation of clots in the legs. Prevention of vertebrobasilar insufficiency includes cessation of smoking, regular exercise, blood pressure control, healthy diet (low cholesterol diet), and management of diabetes. Prevention of dissection includes avoidance of neck manipulation and

trauma to the neck.

The subclavian steal syndrome refers to a combination of neurological symptoms. These symptoms are due to vertebrobasilar insufficiency because of the steal phenomenon, originating from the subclavian artery stenosis proximal to vertebral artery's origin. Endovascular management of supra-aortic atherosclerotic vascular disease is becoming relatively common in the innominate and subclavian arteries. Angioplasty can be proposed to the majority of patients presenting with significant subclavian symptomatic stenosis. The percutaneous procedure is less invasive than surgery and periprocedural complications rates are fewer than those of surgery.

Our experience comes from the endovascular treatment of 129 subclavian arteries in symptomatic patients. It is a relatively easy procedure and complications are rare. Immediately after the procedure the symptoms disappear and the steal syndrome is reversed. Balloon catheter dilation of the proximal subclavian stenosis in symptomatic patients is the treatment of choice, as judged by our own experience and the data in the literature.

Endovascular treatment of vertebrobasilar insufficiency is not routinely performed in peripheral interventional programs. Randomized data comparing medical therapy, endovascular treatment, or surgical treatment do not exist. Our experience comes from the treatment of 52 symptomatic patients with severe >70% vertebral artery stenosis. There was primary technical success in all cases. Cardiological stents were placed in all of these patients. Balloon predilation of the vertebral stenosis was performed in 7 patients followed by stent placement. Follow up (3-36 months) showed two cases of restenosis and all the other patients remain asymptomatic.

We believe angioplasty alone or combined with stenting is the treatment of choice for vertebral artery revascularization due to the high technical success rate, the low incidence of morbidity and mortality, and long-term durability.[5] The available literature demonstrates that angioplasty with stent placement of posterior circulation, in symptomatic, vertebrobasilar atherosclerotic disease, is a safe and effective approach that avoids the morbidity associated with major surgery.[6] Diagnostic angiography of both the posterior and anterior cerebral circulations is required before performing angioplasty. Special attention must be paid to collateral supply from the contralateral vertebral artery, as well as the external carotid artery, from which collaterals may restitute the distal vertebral artery in cases of vertebral occlusion or severe stenosis. Also, patients may have excellent filling of the posterior circulation via the posterior communicating arteries and may tolerate stenosis of one or both vertebral arteries. Considering these possibilities for collateral blood flow, it is not surprising that lesions in the vertebrobasilar system are often asymptomatic and that only a minority of patients will benefit from treatment.[7]

CONCLUSION

The immediate and up to 36 months follow-up results of PTA appear satisfactory. There is also the advantage of a less invasive procedure since surgery has a limited success and excessive morbidity. We believe that we have to treat symptomatic patients with vertebral artery flow-obstructing stenosis that causes brain stem ischemia, and in whom medical treatment failed to resolve the symptoms especially those with concomitant contralateral vertebral severe stenosis >70% or with hypoplastic artery. We conclude also from our results by measuring the rS02 with cerebral oximetry that we have to treat tight vertebral stenosis with left or right severe carotid artery stenosis in order to increase blood flow to the basilar artery. We must also treat symptomatic tight subclavian artery stenosis, or candidates for "bypass" surgery, with balloon expandable stents, to avoid the subclavian steal syndrome from the anterior discending coronary artery through the internal mammary graft.

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