Percutaneous Transluminal Angioplasty and Stent Placement for Subclavian Steal Syndrome With Concomitant Anterograde Flow in the Left Internal Mammary Artery Graft for Coronary Artery Bypass

—Case Report—

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Abstract

A 63-year-old man presented with subclavian steal syndrome associated with left internal mammary artery (IMA) bypass graft to a coronary artery. He was admitted with a history of oppressive sensation in the chest, dizziness, and light headedness on exertion for 2 weeks in March 2002. He had undergone myocardial revascularization consisting of a left IMA-to-left anterior descending coronary artery graft in April 1988. His blood pressure was 140/70 mmHg in the right arm and 80/64 mmHg in the left arm. Aortic arch arteriography revealed complete occlusion of the left subclavian artery proximal to the left IMA takeoff and subclavian steal with anterograde flow of the left IMA. Percutaneous angioplasty and stent placement with protection of the left IMA bypass graft using a balloon catheter was successfully performed without complication by cerebral or myocardial ischemia. Complete recanalization of the occluded left subclavian artery and anterograde flow of the left vertebral artery were achieved. His symptoms disappeared and blood pressure in the left arm recovered. This variant of coronary subclavian steal might require protection of the left IMA during angioplasty and stent placement.

Key words: angioplasty, coronary subclavian steal, subclavian steal syndrome

Introduction

Recently, percutaneous transluminal angioplasty (PTA) with stent placement has gained greater acceptance for the treatment of hemodynamically significant atherosclerotic lesions involving the brachiocephalic, subclavian, and vertebral vessels. PTA is performed instead of extrathoracic bypass surgery, which is associated with several risks and complications,¹³⁾ and many patients are elderly and fragile, which may increase the surgical risk. Over the past decade, the left internal mammary artery (IMA) has become the conduit of choice for coronary bypass surgery due to the long-term patency rates and resistance to atherosclerosis.^{16,20)}

We describe a case of occluded left subclavian

artery with left IMA graft for coronary artery bypass which was successfully corrected by PTA and stenting.

Case Report

A 63-year-old man was admitted to our hospital in March 2002 with a history of oppressive sensation in the chest, dizziness, and lightheadedness on exertion for 2 weeks. He was unable to walk 50 meters due to these symptoms. The patient had undergone myocardial revascularization consisting of a left IMA-to-left anterior descending coronary artery graft in April 1988.

On admission, his blood pressure was 140/70 mmHg in the right arm and 80/64 mmHg in the left arm. No carotid or subclavian bruits were detected. The left radial pulse was weak. Neurological examination revealed no deficits. Angiography showed

Received February 17, 2003; Accepted May 18, 2003

Fig. 1 Aortic arch arteriogram showing complete occlusion of the left subclavian artery proximal to the internal mammary artery takeoff and subclavian steal with antegrade flow in the left internal mammary artery.

the left femoral artery was occluded. Aortic arch arteriography revealed complete occlusion of the left subclavian artery proximal to the left IMA takeoff and subclavian steal with antegrade flow in the left IMA (Fig. 1).

Procedure: A 6-French vascular sheath was inserted into the left axillary artery and an 8-French vascular sheath into the right femoral artery. Heparin (10,000 units) was injected systematically. A 5-French guide catheter (Judkins-R; Goodtec Corp., Gifu) was carefully placed into the left distal subclavian artery via the transaxillary route. A percutaneous transluminal coronary angioplasty (PTCA) guidewire (Miracle 3; Getz Bros. Co., Tokyo) was passed through the occlusion site from the distal subclavian artery to the ascending aorta. A microcatheter (Transit II; Cordis Neuro Vascular, Miami, Fla., U.S.A.) was advanced over the guidewire, which was then removed. Injection of the contrast medium through the microcatheter demonstrated the lumen was the true lumen.

A 0.014 inch/300 cm PTCA guidewire (Grand Slam; Getz Bros. Co.) was inserted into the aortic arch and the microcatheter was removed. The PTCA guidewire was inserted into the abdominal aorta using the 5-French catheter. The PTCA guidewire was lassoed and retrieved via the transfemoral route (Fig. 2A) with a goose neck snare (Amplatz; Microvena Corp., White Bear Lake, Minn., U.S.A.), which was placed in the femoral artery through the

Fig. 2 A: Schematic drawing demonstrating the percutaneous transluminal coronary angioplasty (PTCA) guidewire lassoed and retrieved with the goose neck snare via the transfemoral route. B: Schematic drawing demonstrating the PTCA guidewire placed in the femoral artery. C: Schematic drawing of the protection method during angioplasty and stent placement. D: Schematic drawing demonstrating stent placement combined with the protection method.

8-French guide catheter (pull-through method) (Fig. 2B). Intravascular ultrasonography over the PTCA guidewire revealed that the diameter of the occluded left subclavian artery was 7 mm and that the plaque was the intermediate type. The microcatheter was inserted into the 8-French guide catheter (Britetip; Cordis Endovascular, Warren, N.J., U.S.A.) over the PTCA guidewire via the transbrachial route in the abdominal aorta. The PTCA guidewire was then changed to a 0.016 inch/300 cm guidewire (SV wire; Cordis Endovascular). Then another PTCA guidewire (Grand Slam) was inserted into the left IMA through the 5-French catheter via the transbrachial route, and then a 2.5 mm PTCA balloon catheter (Surpass; Boston Scientific Corp., Maple Grove, Minn., U.S.A.) was introduced to the origin of the left IMA over the PTCA guidewire for protection during the angioplasty procedures. A 6-French guide catheter (Envoy; Cordis Endovascular) within the 8-French guide catheter was placed in the origin of the left subclavian artery via the transfemoral route. A 4.5 mm $\times$ 2 cm PTA balloon catheter (Savvy; Cordis Endovascular) was placed across the lesion through the 6-French catheter over

Fig. 3 Subclavian arteriogram showing that additional postdilation at the proximal portion of the stent caused a funnel shape and cohesion to the vessel wall (arrow).

Fig. 4 Aortic arch arteriogram showing a small dissection of the subclavian artery at the distal end of the stent (arrow).

the SV wire and used to predilate the lesion to allow subsequent passage of a balloon-mounted stent, which was inflated under 8 atm for 30 seconds.

The protection method was combined with these procedures as follows. The PTA balloon was inflated for predilation followed by inflation of the PTCA balloon 15 seconds later. The PTA balloon was deflated after 30 seconds followed by deflation of the PTCA balloon 15 seconds later. This procedure shortened the occlusion time and protected the left IMA (Fig. 2C).

An 8-French guide catheter was placed across the lesion to the distal subclavian artery over the 6-French guide catheter and PTA balloon catheter, which were then removed. The 8-French guide catheter functioned as the outer sheath for stenting. A 4 cm Palmaz stent mounted on a 7 mm $\times$ 4 cm angioplasty balloon (Optapro; Cordis Endovascular) was placed across the lesion. After confirmation of stent positioning, the 8-French guide catheter was retrieved and the stent was deployed by inflation under 10 atm during protection of the left IMA as described previously (Fig. 2D). Since control angiography revealed incomplete expansion of the stent at the proximal portion, the PTA balloon catheter (8 mm $\times$ 2 cm) was inflated there under 10 atm for 30 seconds, which caused the proximal portion of the stent to form a funnel shape and cohere to the vessel wall (Fig. 3). However, there was evidence of small dissection of the subclavian artery of the distal end of the stent (Fig. 4). A second 1 cm Palmaz stent mounted on a 7 mm $\times$ 2 cm angioplasty bal-

Fig. 5 Aortic arch arteriogram showing excellent patency of the left subclavian artery after additional stent placement.

loon was then deployed under 8 atm combined with the protection method, resulting in excellent angiographic patency of the left subclavian artery with anterograde filling of the left vertebral artery (Fig. 5).

Postoperative course: The patient was treated with aspirin and ticlopidine prior to and following angioplasty and given heparin by continuous intravenous infusion for 24 hours postoperatively. The symptoms of oppressive sensation in the chest, dizziness, and lightheadedness disappeared. His blood pressures was 134/60 mmHg measured bilaterally.

Discussion

Subclavian steal syndrome involves proximal subclavian artery obstruction, reversal of flow in the vertebral artery with resultant siphoning of blood from the brain, and symptoms of cerebral ischemia.¹⁷⁾ The increased use of the left IMA for myocardial revascularization has exposed another type of subclavian steal syndrome termed "coronary subclavian steal."^{5,12)} Coronary subclavian steal features the same pathological anatomy, with proximal subclavian artery stenosis or occlusion, but the steal consists of siphoning of blood from the myocardium through the left IMA graft to the subclavian artery, with resulting myocardial ischemia.²⁸⁾ The incidence of coronary subclavian steal in patients undergoing left IMA grafts for coronary artery bypass is estimated to be 0.44%,³⁴⁾ and 32 cases of coronary subclavian steal have been reported.^{3-5,10,11,14,19,22,24-31,33,35)} Another type of subclavian occlusive disease is associated with left IMA graft to a coronary artery. Proximal stenotic lesions of the subclavian artery can cause reduction of flow within the left IMA graft and result in myocardial ischemia with or without reversal of flow within the vertebral artery with consequent vertebrobasilar insufficiency. This syndrome has been termed a variant of coronary subclavian steal.¹⁸⁾

Our patient presented with subclavian steal syndrome due to occlusion of the proximal subclavian artery, but the flow in the left IMA graft was antegrade. Therefore, our case was not coronary subclavian steal but a variant of coronary subclavian steal. Seven cases of variant of coronary subclavian steal have been reported including the present case. Three patients were treated with PTA,^{8,19,32)} two with stenting,^{18,29)} and one with subclavian-subclavian artery bypass.¹¹⁾ Our patient required treatment to increase flow through the left IMA-coronary bypass.

Carotid-subclavian bypass has a mortality of 5% with a complication rate of 15% to 25% including stroke, neck lymph fistula, phrenic nerve paresis, and Horner syndrome.^{2,9,13)} Review of 118 reported cases of subclavian artery PTA revealed a high technical success rate (95%), a low major complication rate, i.e., occlusion and embolism, of 5%, and a low restenosis rate of 10% during follow up for as long as 10 years.^{7,15,23,28,36)}

Angioplasty carries the risk of embolization caused by debris via the vertebral artery, but flow through the vertebral artery is not reversed immediately after dilation of the subclavian artery stenosis.^{1,6,21,28)} Especially in patients with subclavian steal syndrome, flow within the vertebral artery does not become antegrade immediately, but over

a period of 20 seconds to several minutes. Delayed flow reversal serves as a protective mechanism against cerebral embolism during and shortly after PTA of the subclavian artery.²⁸⁾ However, the steal flow in our patient was antegrade in the left IMA, which functioned as the coronary bypass graft from the distal subclavian artery. Since distal embolism to the myocardium during the procedure can cause fatal myocardial infarction, protecting the left IMA seemed to be necessary.

Placement of a protective PTCA balloon in the left IMA was easy. Debris can accumulate in the space between the origin of the IMA and the protective PTCA balloon, so the protective balloon was placed at the origin of the left IMA to prevent distal embolism to the myocardium. Although one-minute occlusion of the flow to the coronary artery seemed possible in our patient based on experience with previous PTCA procedures, we used a shorter occlusion time of the left IMA by delay between the inflation-to-deflation time of the PTA balloon and the protective balloon. Although protection is not necessary in patients with coronary subclavian steal because of reverse flow in the left IMA, it might be necessary in patients with variant coronary subclavian steal because of the antegrade flow in the left IMA.

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