Improving Infrapopliteal Balloon Angioplasty Results

A new generation of long balloons for treating diabetics and nondiabetics.

BY LANFROI GRAZIANI, MD

Approximately 6% to 8% of the Western population is affected by diabetes, and this number is expected to double during the next 20 years.[1] Seventy percent to 80% of all deaths among diabetics are related to cardiovascular disease, with myocardial infarction occurring in 50% of all cases.[2]

According to the CODE 2 European Study in 2000, the yearly cost of the care of a single diabetic patient is approximately $5,244.52 (€3.873,00)—more than double the average sanitary cost per citizen.[3] The annual average cost for a diabetic without complications is $2,049.21 (€1.485,00). In the case of a single macrovascular complication, the cost increases to $5,383.16 (€3.901,00); with a single microvascular complication, the cost increases to $7,147.93 (€5.180,00), and with both types of complications, it reaches $9,615.20 (€6.968,00).

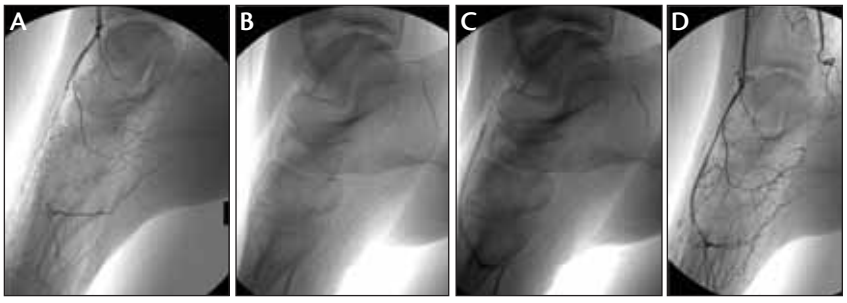

Figure 1. A 53-year-old diabetic woman with CLI and necrotic foot ulcer. Occlusion of both the posterior tibial and peroneal arteries and an occlusion of the dorsalis pedis artery (A). From the anterior tibial artery, a 2-mm X 80-mm balloon was advanced along the plantar arch over a .014-inch coronary wire (B). The balloon was inflated at 14 atm for 3 minutes (C). Complete recanalization of the dorsalis pedis artery (D).

LOWER-EXTREMITY VASCULAR DISEASE AMONG DIABETICS

Peripheral arterial disease (PAD) is more common in diabetics, and it presents in younger patients with less difference between genders. It has a faster progression to critical limb ischemia (CLI), it is multilevel, and more distal.[4] In diabetics, arterial collateral formation is significantly decreased or absent, and this inability could explain why most patients with CLI are diabetics.[5-7] The ischemic diabetic foot ulcer is the primary cause of nontraumatic amputations in the US for patients aged between 65 and 74 years. Approximately 20% of subjects with diabetes develop CLI and ischemic foot ulcers during their lives, and 33% of them, if untreated, eventually undergo an amputation, with a 20% mortality rate within 6 months.[8-11] PAD in patients with diabetes presents specific characteristics in terms of histopathological features and anatomical distribution of the obstructive lesions. In 417 consecutive CLI diabetic subjects with ischemic foot ulcers undergoing lower-limb angiography, out of the 2,893 lesions (55% occlusions), 1% were in the iliac arteries, and 74% were in below-the-knee (BTK) arteries. Sixty-six percent of all BTK lesions were occlusions, and 50% were long occlusions (>10 cm long). Occlusions of all BTK arteries were present in 28% of patients.[12]

Using the suggested new morphologic classification, class 4 (two arteries occluded and multiple stenoses of tibioperoneal and/or femoropopliteal vessels) and class

6 (three arteries occluded and multiple stenoses of tibioperoneal and/or femoropopliteal arteries) were the most common conditions (63%). These data underline the typical multilevel severe obstructive burden of CLI in diabetic subjects that require, in cases of endovascular treatment, different techniques and devices used during the same procedure. Therefore, studies specifically addressing a single technique and/or device in this population, such as drug-eluting stents, could depend on the concomitant treatment of other vascular segments with different techniques. This has to be considered, judging the real impact of that technique/device on the outcome.

Diabetic arteriopathy is characterized by diffuse vessel wall thickening due to connective degeneration and medial (homogeneous and macrophage-free) calcification, characterized by increased amounts of connective tissue (fibronectin, collagen, and glycoproteins) and calcium in the medial layer. A constellation named *diabetic macroangiopathy* is commonly found in BTK arteries.[13,14] Atherosclerotic lesions, common in iliac and femoropopliteal segments, are characterized by asymmetric plaque distribution and extension, with focal-eccentric (irregular) subintimal and medial atherosclerotic degeneration and macrophage atheromatous plaque colonization.

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Therefore, despite the severity and multilevel diffusion of peripheral arterial lesions, the specific characteristics of diabetic arteriopathy could in fact facilitate a very good immediate angiographic result using plain old balloon angioplasty (POBA). A stent-like appearance afterward could be frequently achieved even by dilating extremely long and calcified tibial arterial stenoses and occlusions in diabetics. Even the long-term clinical results could be favorable, performing extensive extreme interventions, including recanalization in the leg and foot arteries (Figure 1). Chronic tibial artery occlusion recanalization is currently performed crossing the lesion using .014-inch coronary-type hydrophilic stiff guidewires, then is followed by dilatation using balloons of 1.5 mm to 3.5 mm in size (Figure 2). Subintimal recanalization is less frequently used in tibial territories (5% to 7% of our cases). To achieve a good angiographic result, prolonged dilatation time (180 seconds) is commonly used. In cases with unsatisfactory results (residual stenosis >30% and/or flow-limiting dissection), a new prolonged high-pressure (≤20 atm) dilatation is performed. Tibial artery stenting currently accounts for approximately 2% to 3% of our performed procedures.

Figure 2. Extensive occlusion of all leg and foot arteries in a 65-year-old diabetic man with CLI and a foot ulcer (A,B). Optimal angiographic result after POBA, using 3-mm X 120-mm and 2.5-mm X 80-mm-long balloons (C,D).

In our results from a consecutive series of 1,191 diabetic patients with CLI referred for endovascular consultation, POBA and provisional stenting were feasible in 84%, and during a median follow-up of 23 months, the major amputation rate was only 1.7% (4% on intention-to-treat analysis).[15] The clinical recurrence rate was 11.3%, whereas the cumulative 5-year primary patency rate was 88%. Bypass surgery was performed in 157 patients (13.2%) with an 8.3% major amputation rate. Of the 47 subjects not revascularized (five anesthesiology risk, four patient refusal; 38 were not considered by the vascular surgeon as candidates for bypass surgery), 34% underwent major amputation. In 85.4% of clinical recurrences, a second POBA and/or stenting was successfully performed. The specific characteristics of diabetic macroangiopathy have, for many years, represented an obstacle for the application of endovascular techniques in arteries of the lower limb. In particular, the considerable length of the lesions, often represented with calcified occlusions, has discouraged more than one skilled interventionist. The clinical evidence is clear: if direct flow along the leg arteries is not re-established, the ischemic ulcerative foot lesions cannot heal, and the risk of major amputation persists. Thus, the unavoidable decision is to select the balloon catheters of suitable length to obtain a homogenous remodeling of the treated arteries.

SMALL-VESSEL BALLOONS

The limitation of the first generation of small-vessel balloons is that it was only a faint attempt to imitate the diameter and technical characteristics of a coronary artery

Figure 3. A 62-year-old man on chronic hemodialysis with CLI and an ischemic foot ulcer. Diffuse occlusion of most of the leg and foot arteries (A,B). Complete recanalization of the posterior tibial and plantar arteries using a 3-mm X 120-mm balloon at 13 atm for 6 minutes (C,D).

balloon angioplasty catheter. The crucial moment in the development and improvement of these instruments for leg vessels occurred when their construction followed the same model used for coronary angioplasty. The relevant characteristics were extremely low profile, the tip was tapered to .014-inch, and the balloon length (according to the length of the lesions to be treated) had reached 120 mm and, very recently, 150 mm to 210 mm. The best pushability characteristics have been obtained by adopting the over-the-wire structure. The technical characteristics adopted for these new balloons were the low compliance and the ability to sustain medium-high pressure, improving the remodeling of the treated vessel—especially adopting the technique of prolonged inflation. This allowed spectacular progress in obtaining good angiographic and clinical results in a population with a high risk of major amputation.

DISCUSSION

The use of these sophisticated instruments has facilitated good results, even in the treatment of extreme lesions in dialyzed subjects with critical peripheral ischemia (Figure 3).

This population, which very often presents with the combination of uremic arteriopathy and diabetic macroangiopathy characteristics, probably represents the most difficult challenge for even an expert interventionist. In this population, according to our previous report, immediate technical success can be achieved in 97% of cases, with cumulative limb salvage rates (median follow-up, 22 months) at 12, 24, 36, 48 months of 86%, 84%, 84%, and 62%, respectively.[16] Limb salvage without any new intervention on the same leg was achieved in 70% of cases, and new interventions were performed on 23 (17%) legs. Major amputation during follow-up was necessary for 20 (15.1%) limbs. The new generations of long balloons have furthermore allowed the treatment of foot artery obstructions in subjects with ischemic foot ulcers. A new alternative technique of revascularization in the most difficult cases is represented by the dilatation of peroneal collateral branches to the foot to obtain a direct flow to the plantar or dorsalis pedis arteries.[17] This new technique requires the use of the new long balloons, thus keeping the risk of major amputation extremely low in subjects with CLI. ■

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1. International Diabetes Federation. Diabetes Atlas. 2000;8196:132.
2. DeStefano F, Ford ES, Newman J, et al. Risk factors for coronary heart disease mortality among persons with diabetes. Ann Epidemiol. 1993;3:27-34.
3. Studio Europeo CODE 2 Working Group: il costo sociale del diabete tipo 2 in Italia. PharmacoEconomics, Italian Research Articles. 2000;1;1-21.
4. LoGerfo FW, Coffman JD. Vascular and microvascular disease in the diabetic foot: implications for foot care. NEJM.1984;311:1615-1619.
5. Abaci A, Kahraman S, Eryol NK, et al. Effect of diabetes mellitus on formation of coronary collateral vessels. Circulation. 1999;99:2239-2242.
6. Waltenberger J. Impaired collateral vessel development in diabetes: potential cellular mechanisms and therapeutic implications. Cardiovasc Res. 2001;49:554-560.
7. Weihrauch D, Lohr NL, Mraovic B, et al. Chronic hyperglycemia attenuates coronary collateral development and impairs proliferative properties of myocardial interstitial fluid by production of angiostatin. Circulation. 2004;109:2343-2348.
8. Diabetes-related amputations of lower extremities in the Medicare population of Minnesota, 1993-1995. MMWR Morb Mortal Wkly Rep.1998;47:649-652.
9. Levin ME. Preventing amputation in the patient with diabetes. Diabetes Care.1995;18:1383-1394.
10. Apelqvist J, Bakker K, van Houtum WH, et al. International consensus and practical guidelines on the management and the prevention of the diabetic foot. International Working Group on the Diabetic Foot. Diabetes Metab Res Rev. 2000;16(suppl 1):S84-S92.
11. Dormandy JA, Rutherford RB. Management of peripheral arterial disease. TASC Working Group. J Vasc Surg. 2000;31(suppl):S1-S296.
12. Graziani L, Silvestro A, Bertone V, et al. Vascular involvement in diabetic subjects with ischemic foot ulcer: a new morphologic categorization of disease severity. Eur J Vasc Endovasc Surg. 2007;33:453-460.
13. Shanahan CM, Cary RB, Salisbury JR, et al. Medial localization of mineralization-regulating proteins in association with Mönckeberg's sclerosis: evidence for smooth muscle cell–mediated vascular calcification. Circulation.1999;100:2168-2176.
14. Defronzo RA, Ferrannini E, Keen H, et al. International Textbook of Diabetes Mellitus. Chichester, England: John Wiley & Sons Ltd. 1992:1435-1446.
15. Faglia E, Dalla Paola L, Clerici G, et al. Peripheral angioplasty as the first-choice revascularization procedure in diabetic patients with critical limb ischemia: prospective study of 993 consecutive patients hospitalized and followed between 1999 and 2003. Eur J Vasc Endovasc Surg. 2005;29:620-627.
16. Graziani L, Silvestro A, Bertone V, et al. Percutaneous transluminal angioplasty is feasible and effective in patients on chronic dialysis with severe peripheral artery disease. Nephrol Dial Trans. 2007;22:1144-1149.
17. Graziani L, Silvestro A, Monge L, et al. Transluminal angioplasty of peroneal artery branches in diabetics: initial technical experience. Cardiovasc Interv Radiol. 2007. Accepted for publication.