ELSEVIER

Long-Term Outcomes of Direct and Indirect Below-The-Knee Open Revascularization Based on the Angiosome Concept in Diabetic Patients with Critical Limb Ischemia

Anne Lejay,[1] Yannick Georg,[1] Elvira Tartaglia,[1] Sébastien Gaertner,[2] Bernard Geny,[3] Fabien Thaveau,[1] and Nabil Chakfe,[1] Strasbourg, France

Background: We compared long-term outcomes of isolated below-the-knee (BTK) bypass revascularization in diabetic patients presenting with critical limb ischemia (CLI) with and without achieving the bypass on the artery corresponding to the territory of the lesion based on the angiosome concept.

Materials: We analyzed outcomes of 58 consecutive CLI limbs of 54 diabetic patients presenting with tissue loss who underwent isolated BTK bypasses from 2003 to 2009 for crural occlusive arterial disease. Bypasses were classified into direct and indirect groups based on the angiosome concept, whether feeding artery flow to the site of ischemic tissue loss was achieved or not. We compared median ulcer-healing time, survival, primary patency, and limb salvage rates between both groups by Kaplan–Meier analysis and log-rank test. Independent factors of major amputations were explored by univariate analysis. Variables with $P < 0.2$ in univariate analysis were submitted to multivariable analysis.

Results: Median ulcer-healing time was 56 ± 18 days in direct group ($n = 36$) and 112 ± 45 days in indirect group ($n = 22$, $P = 0.01$). There was no difference between both groups in terms of survival or primary patency. Limb salvage rate was significantly higher in direct group than in indirect group: 91% vs. 66% at 1 year, 65% vs. 24% at 3 years, and 58% vs. 18% at 5 years, respectively ($P = 0.03$). After multivariable Cox proportional analysis, independent factors associated with major amputation were end-stage renal disease ($P = 0.030$) and C-reactive protein level ($P = 0.025$).

Conclusions: Achieving a direct arterial flow based on angiosome concept in CLI diabetic patients presenting with tissue loss appears to be important for ulcer healing and limb salvage.

INTRODUCTION

Etiology of tissue loss in diabetic patients is multifactorial, including neuropathy and infection. Therefore, the basic factor preventing healing of a diabetic foot ulcer is often inadequate perfusion.[1] In diabetic patients, arterial occlusive disease primarily affects crural arteries.[2] In the Bypass versus Angioplasty in Treatment of Severe Leg Ischaemia trial, which examined critical limb ischemia (CLI) with infrainguinal arterial occlusive disease, the selection of the revascularization strategy was based on the presence of suitable vein and life expectancy.[3,4] There is also increasing evidence that

[1]*Department of Vascular Surgery and Kidney Transplantation, Les Hôpitaux Universitaires de Strasbourg, University of Strasbourg, Strasbourg, France.*

[2]*Department of Hypertension and Vascular Diseases, Les Hôpitaux Universitaires de Strasbourg, University of Strasbourg, Strasbourg, France.*

[3]*Department of Physiology, Les Hôpitaux Universitaires de Strasbourg, University of Strasbourg, Strasbourg, France.*

Correspondence to: Anne Lejay, MD, Department of Vascular Surgery and Kidney Transplantation, Nouvel Hôpital Civil, BP 426, 67091 Strasbourg Cedex, France; E-mail: anne.lejay@chru-strasbourg.fr

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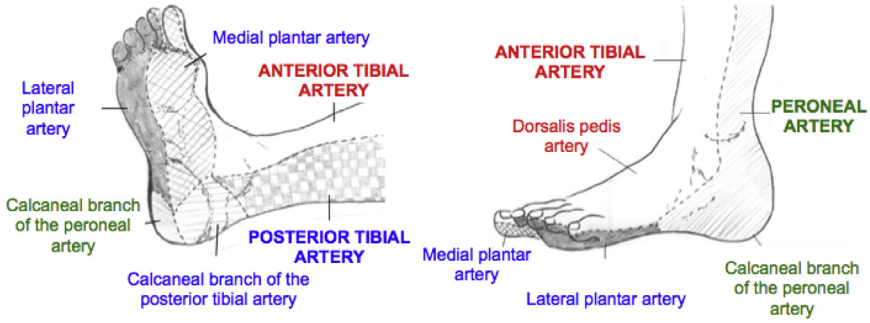

Fig. 1. Angiosome concept.

the angiosome concept is clinically useful for limb salvage in CLI patients. The angiosome concept, defined by Taylor in his landmark anatomic study in 1987, divides the body into three-dimensional anatomic units of tissue supplied by specific source arteries.[5] The foot can be divided into 6 angiosomes: three arising from the posterior tibial artery, one from the anterior tibial artery, and two from the peroneal artery. The anterior tibial artery supplies the dorsal side of the foot and the toes, the peroneal artery covers the lateral ankle and lateral heel, and the posterior tibial artery perfuses the medial ankle and medial heel, the plantar surface of the foot, and the plantar surface of the toes.[6] (Fig. 1). In open and endovascular revascularization modalities, achievement of sufficient direct blood flow to the ulcer based on the angiosome concept results in a high limb salvage rate. However, in clinical practice, achievement of this direct arterial perfusion with angioplasty appears limited compared with bypass surgery.[7,8] It is also often believed that the blood supplied by a bypass graft is sufficient to fill the entire foot, regardless of the angiosome concept. The purpose of this study was to evaluate if infrapopliteal open revascularization guided by the angiosome model of perfusion has a beneficial effect on the healing process and limb salvage in patients with diabetic foot ulcers presenting with CLI.

MATERIALS AND METHODS

Patients

Patients who underwent distal bypass surgery from 2003 to 2009 for crural arterial occlusive disease were identified. We specifically selected diabetic patients, who underwent venous bypasses. A total of 58 consecutive CLI limbs with distal to the malleolar foot ulcer in 54 diabetic patients who underwent distal bypass surgery from 2003 to 2009 for crural arterial occlusive disease were thus retrospectively analyzed.

Foot Lesions

The diagnosis of CLI was made according to TASC II recommendations,[9] based on nonhealing tissue loss with hemodynamic evidence of ischemia (skin perfusion pressure). Foot ulcer was defined as a full-thickness skin defect distal to the malleolar level present for at least 3 weeks. Diabetic foot Armstrong classification was used for classifying the depth of the foot ulcer (grade 1, superficial ulcer; grade 2, penetrating ulcer; grade 3, ulcer penetrating to muscle, tendon, or joint articulation; and grade 4, ulcer penetrating to bone) and the presence of infection (stage A, nonischemic noninfected ulcer; stage B, nonischemic infected ulcer; stage C, ischemic noninfected ulcer; and stage D, ischemic infected ulcer).

Angiosome Concept and Revascularization Procedure

All patients had preoperative angiography and isolated below-the-knee (BTK) lesions. The locations of foot ulcer and the angiosome-based favorable target lesion were noted. The presence or absence of a pedal arch was noted. Bypasses were classified into direct and indirect groups based on the angiosome concept, whether feeding artery flow to the site of ischemic tissue loss was achieved or not. If the foot ulcer extended over more than one angiosome territory, the leg was considered to belong to the direct group if direct flow to the ulcer from at least one crural artery was achieved with bypass surgery. All distal bypasses were conducted using saphenous vein grafts. An immediate preoperative angiography was done for all patients. Minor amputation was done when necessary 2 weeks after revascularization.