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Foot Skin Blood Flow Following Infrainguinal Revascularization for Critical Lower Limb Ischemia

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Introduction. *The aim of this study was to assess the blood flow in the feet before and after lower limb revascularization using laser Doppler imaging (LDI).*
Methods. *Ten patients with critical lower limb ischemia were prospectively enrolled from June to October 2004. All patients underwent successful unilateral surgical interventions including above-knee bypass, distal bypass and endarterectomy. Skin blood flow (SBF) over the plantar surface of both forefeet and heels was measured by LDI 24 h before and 10 days after revascularization, expressed in perfusion units (PU), and reported as mean ± SD.*
Results. *Measurements in the forefoot and heel were similar. Before revascularization mean SBF was significantly lower in the ischemic foot (130 ± 71 PU) compared to the contralateral foot (212 ± 68 PU), $p < 0.05$. After revascularization a significant increase of the SBF in the forefoot (from 135 ± 67 to 202 ± 86 PU, $p = 0.001$) and hindfoot (from 148 ± 58 to 203 ± 83, $p = 0.001$) was observed on the treatment side. However, a large decrease of the SBF was seen in forefoot and hindfoot on the untreated side (from 250 ± 123 PU to 176 ± 83 and from 208 ± 116 to 133 ± 40, $p = 0.001$, respectively).*
Conclusion. *This study confirms the benefits of revascularization in patients with nonhealing foot lesions due to critical limb ischemia. A significant increase of the SBF was observed on the treatment side. However, an unexpected decrease was observed on the untreated side.*

Keywords: Laser doppler imaging; Foot skin perfusion; Critical limb ischemia; Infrainguinal bypass.

Introduction

Current revascularization techniques have greatly improved limb salvage rates in patients with critical lower limb ischemia.[1] However, some authors have reported poor outcome with major amputation despite infrainguinal bypass.[2,3] Poor outcome have been particularly reported in patients with chronic renal failure or diabetes, with distal anastomosis sites or in the presence of infection.[4] In diabetic patients, the failure to improve functional ischemia following successful bypass grafting surgery is associated with an endothelial dysfunction and an ensuring impaired vasodilatation.[5]

One of the major aims of lower limb revascularization in patients with critical ischemia is to prevent or heal ulcer and gangrene by improving arterial pressure and flow. Healing of skin lesions on the foot depends on effective restoration of cutaneous microcirculation. Doppler and plethysmographic techniques used to assess the hemodynamic impact of vascular reconstructive surgery give little information about skin capillary hemodynamics.

The utility of laser Doppler flowmetry in assessing skin blood flow (SBF) has been proposed in previous studies.[6–9] However, standard laser Doppler flowmetry uses an optical fiber apposed in close contact to the skin. For this reason, it cannot be used for the global assessment of blood flow over a large surface (e.g. the whole foot sole as would be appropriate to evaluate results of revascularization surgery). More recently, a technique known as laser Doppler imaging (LDI) has been introduced.[10,11] The purpose of this study was to use LDI for bilateral assessment of SBF before and after infrainguinal revascularization in patients with critical limb ischemia.

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Table 1. Demographic data

Median age (range)	77 (94–64)
Sex ratio (M:F)	5:5
Risk factors	
Smoking	5
Hypertension	9
Diabetes	3
High cholesterol	4
Chronic renal failure	5
Mean preoperative plethysmography (mmHg)	21 (0–35)
Mean hospitalization time (days)	12 (4–35)

Table 2. Preoperative arteriography results

Number of patent distal vessels	
Three	1
Two	4
One	5
Patent pedal arch artery	1
Patent deep plantar arch artery	7
Patent anterior tibial artery	5
Patent posterior tibial artery	5
Patent peroneal artery	6

Material and Methods

Ten patients scheduled to undergo infrainguinal revascularization for critical lower limb ischemia were prospectively enrolled in this study between June and October 2004. Demographic data are summarized in Table 1. Plethysmography was performed to determine toe pressure before and 10 days after revascularization in all cases as well as ankle brachial index pressure. Preoperative angiography or MRI with gadolinium was performed in all patients with chronic renal failure. The patency of distal vessels and the pedal and deep plantar arch arteries (Table 2) was assessed by arteriography or MRI in all patients. The infrainguinal revascularization procedures were performed above the knee in five patients (by endarteriectomy in four patients and femoro-popliteal bypass in one patient). Distal bypass was performed in five additional patients. All patients underwent duplex scan to assess bypass patency 7 days after surgery.

The laser Doppler imager (Moor Instruments, Axminster, UK) used in this study is designed for noncontact visualization of blood perfusion. The predetermined area of interest (AOI) is scanned using a visible red helium–neon laser beam (wavelength, 632.8 nm) emitted at a distance and reflected onto the skin by a computer-controlled mobile mirror. Imaging is achieved by analyzing photon backscatter to determine flux values in each of several thousands points within the AOI. Flux values are proportional to SBF and expressed in perfusion units according to the principle of laser Doppler flowmetry. Flux data are converted into color-coded perfusion maps. In addition, analysis of the DC component of the backscattered light allows generation of a grey level photographic image of the named area (Fig. 1).

Assessment of SBF on both foot soles was carried out a few hours (less than 24) before surgical revascularization (day 1) and 10 days after revascularization (day 2). The same protocol was used on both days. Skin temperature was systematically monitored using a cutaneous sensor (G. Mettraux, Crissier, Switzerland). Temperature and relative humidity were maintained at 23 °C and 60%, respectively, by the hospital air conditioning system. Distance from laser source to skin was 70 ± 10 cm depending on foot size and conformation. Time for calculation of a single pixel was 4 ms allowing for an approximate distance of 2 mm between pixels. Although the Doppler imager used is reasonably insensitive to ambient lighting, measurements were

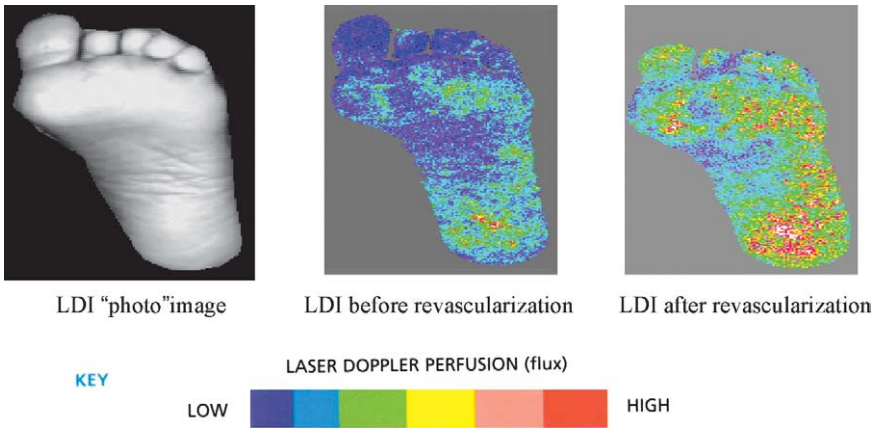

Fig. 1. LDI scanning.

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