

Minor amputations on the feet after revascularization for gangrene

A consecutive series of 95 limbs

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A consecutive series of 89 patients (95 limbs) with gangrene were operated on with amputation of toes or some distal part of the foot after arterial reconstruction. 43 patients had diabetes. Healing was achieved in 81/82 feet when the reconstruction was open. Amputation below or above the knee was required in 4/5 limbs when the reconstruction failed. 8 patients died before healing. The median time to

healing was 30 (17–452) days, after a single amputation, and 115 (36–466) days, when more than one procedure had been necessary. We concluded that amputations on the feet for gangrene usually heal after arterial reconstruction, in patients with diabetes as well as in those with arteriosclerosis. No weight bearing and control of infection are important during the early postoperative period.

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During recent decades, the number of major amputations has decreased in patients with arteriosclerosis (Pedersen et al. 1994, Holstein et al. 1996) and diabetes (Larsson and Apelqvist 1995). This is partly due to better results in infrapopliteal arterial reconstructions (Ebskov et al. 1994). In many cases, after revascularization of the foot, necrotic tissue can be removed close to the demarcation line and thus part of the foot may be saved. The frequency of healing after minor amputations varies from 50% (Hobson et al. 1990) to more than 80% (Pinzur et al. 1986); only few articles have been published about amputations on the feet after vascular surgery (Miller et al. 1991). We report our results concerning distal amputations after vascular reconstructions.

European consensus document on chronic critical ischemia (1992) were fulfilled—i.e., digital pressure $\leq$ 30 mmHg and/or an ankle pressure $\leq$ 50 mmHg. Most revascularizations were infrainguinal and 16 limbs had to be reoperated because of graft occlusion (Table 1). The median time between the revascularization procedure and the foot surgery was 6 (0–104) days. 17 patients were amputated at the same time as the vascular procedure. 9 of these were diabetics with infection requiring immediate drainage. In 41 feet, the wound was left open for secondary healing. Antibiotic treatment with dicloxacillin 1 g $\times$ 2 and ampicillin 1 g $\times$ 2 was started preoperatively and continued for about 1 week if the wound was closed primarily; if the

Patients and methods

From 1988 to 1990, 85 consecutive patients (95 limbs) had foot surgery for peripheral gangrene after revascularization by arterial reconstruction or by angioplasty. The median age was 73 (39–94) years. 43 patients had diabetes. The male/female ratio was 2. The indication for revascularization was progressive gangrene in all cases. Measurement of the systolic ankle blood pressure and, if possible, the systolic toe pressure with strain gauge technique, was made before arterial reconstruction and repeated before the foot surgery. In 90 cases, the criteria of the second

Table 1. Arterial revascularization procedures in 95 limbs with gangrene

First reconstruction	n	Reoperation
<i>Above inguinal ligament</i>		
Angioplasty	2	
Thrombendarterectomy	1	
Bypass	3	1
<i>Below inguinal ligament</i>		
Angioplasty	22	
Thrombendarterectomy	1	
Femoropopliteal bypass	26	5
Infrapopliteal bypass	36	9
<i>Combined above and below inguinal ligament</i>	4	1
Total	95	16

wound was left open, the treatment continued until it was covered with granulation tissue.

Weight bearing was allowed when the wound had healed or at least was covered with granulation tissue. If the wound was localized to the toes or forefoot, however, limited walking using a therapeutic shoe with a high heel was allowed after 1–2 weeks.

The chi-square test was used to calculate differences in healing and complications between patients with diabetes and those with arteriosclerosis.

Results

8 patients died before the wound had healed. 6 died in hospital after a median of 58 (31–122) days and 2 died after discharge from hospital, i.e., after 194 and 209 days, respectively.

16 limbs had to be reoperated due to occlusion of the first reconstruction (Table 1). 4/5 limbs with persistent graft occlusion had to be amputated, 3 below and 1 above the knee. In the fifth case, occlusion of a femoropetal bypass in a diabetic patient resulted in severe necrosis, but the patient had no pain and the wound healed slowly over a period of more than 1 year. In patients with open reconstructions, we found only 1 below-the-knee amputation. This was a patient with diabetes who had progressive gangrene, in spite of good ankle and digital pressures and no infection.

In surviving patients with open arterial reconstructions, the wound healed in 81/82 feet. 62/87 feet healed distal to level of the forefoot (Table 2). The amputations included the first toe in 26 of 95 feet.

In 57/87 limbs healing occurred after the first operation after a median of 30 (17–452) days. In 25 limbs, 2 or more revisions were necessary and in this group the median healing time was 115 (36–466) days. When the wound was sutured primarily (53 feet), the median healing time was 38 (17–466) days, and when the wound was left open it was 78 (19–452) days.

The amputations healed at foot level in all cases but one, where the digital pressure had increased to more than 20 mmHg (Table 3).

There were no statistically significant differences between patients with diabetes and those with arteriosclerosis, regarding mortality, healing at foot level, blood pressure measurements and time to healing.

Discussion

Healing after amputation of a part of the foot in a patient with occlusive arterial disease has been reported as poor. Gianfortune et al. (1985) found a success rate

Table 2. Primary and final levels of amputation in 95 limbs with gangrene

	Primary level	Final level	Dead before healing
Partial digital	25	20	2
Digital disarticulation	3	3	–
Ray resection	47	34	5
Combined	6	5	1
Transmetatarsal forefoot	12	14	–
Tarsal	2	3	–
Syme's	–	3	–
Below knee	–	4	–
Above knee	–	1	–
Total	95	87	8

Table 3. Systolic ankle blood pressure and systolic digital blood pressure before and after revascularization in 87 limbs in surviving patients, grouped according to Holstein and Lassen (1980) and Holstein (1984)

	Before	After	Major amputation
<i>Ankle pressure (mmHg)</i>			
< 50	26	3	2
50–99	51	22	1
≥ 100	4	52	1
Not measured	6	10	1
Total	87	87	5
<i>Digital pressure (mmHg)</i>			
< 20	58	7	4
20–29	16	8	–
≥ 30	7	42	1
Not measured ^a	6	30	–
Total	87	87	5

^a because of gangrene/amputation of the big toe.

after ray resections of only one third. Healing rates of about 50% after transmetatarsal amputations have recently been reported (Hodge et al. 1989, Hobson et al. 1990). Hobson et al. (1990) observed that even functioning femoropopliteal grafts did not improve the results. Miller et al. (1991) reported limb salvage in 62% after revascularization and transmetatarsal amputations. When the grafts remained open, the success rate was 83% which was similar to our observations.

Failed healing together with an adequate blood supply occurs in about 15–30% (Boeckstyns and Jensen 1984, Holstein 1984, Hodge et al. 1989, Hobson et al. 1990, Larsson et al. 1993). The reasons may be infection (Holstein 1984) and probably wound breakdown on early weight bearing. In our experience, the regimen of no weight bearing must be properly carried out. In the only series with a healing rate comparable to ours, casts were used during mobilization (Pinzur et al. 1986). Casts, however, may prevent monitoring of an arterial reconstruction and therefore we prefer to

postpone weight bearing. Finally, attention to footwear is necessary, particularly in the insensitive diabetic foot.

Although we obtained a high rate of healing, the time to healing was considerable and secondary revisions were often necessary. It is difficult to judge the viability of the tissues close to gangrene during the operation. The increase in peripheral blood supply is somewhat delayed after an arterial reconstruction (Noer et al. 1980, Holstein et al. 1991). The amputation should therefore be postponed, preferably to about 1 week after the reconstruction, unless invasive infection requires urgent drainage.

It is of decisive importance for rehabilitation that minor amputations do not fail (Larsson 1994). The literature on this subject is surprisingly sparse and controlled trials are lacking. Autoamputation is an alternative to operative treatment, but we have found that autoamputation of gangrenous toes in diabetics in many cases is complicated with invasive infection. In non-diabetics, autoamputation is commonly a painful process that may take many months. For these reasons, we abandoned autoamputation a number of years ago and we prefer early surgical revision. This policy and a number of other details in our program have never been evaluated in randomized series. Satisfactory results would probably be obtained with other regimens as well. The long healing periods noted in this study might be shortened. Reduced morbidity would be important, also from an economic point of view (Apelqvist et al. 1994).

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