Treatment of the ischemic hand in frostbite by revascularization with interpositional vein graft and digital palmar sympathectomy: A case report

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In severely ischemic hands where the microcirculation is not amenable to reconstruction, there is evidence that palmar digital sympathectomy has salutary effects. This report describes the case of a patient with a painful, ulcerated, ischemic hand secondary to ulnar artery stenosis, generalized vasospasm and intimal hypertrophy that resulted from cold injury. Surgical treatment involved an interpositional vein graft replacing a thrombotic segment of the ulnar artery and concomitant palmar digital sympathectomy. The coupling of these two microvascular procedures completely relieved the patient’s symptoms, increased total blood flow and improved the vascular function of the hand. The combination of reconstruction of an occluded vessel with peripheral sympathectomy in treating difficult cases of ischemic hand injury is recommended.

Key Words: Frostbite; Hand; Ischemia; Palmar digital sympathectomy; Vein graft

A 65-year-old man presented with pregangrenous finger-tips of his left hand. The left index finger had ulcerated on the palmar tip, and the other fingers had a bluish discolouration (Figure 1). These ischemic changes were associated with pain, requiring analgesics.

The patient stated that his condition began approximately one year before presentation, while moose hunting in northern Ontario. On this expedition, his hands suffered severe frostbite, but he continued hunting despite recognizing the problem. He had suffered similar insults to his hands on previous yearly hunting trips, but to a lesser degree. The patient had a 53 pack-year smoking history but had stopped smoking soon after the consultation. He also had a long-standing history of hypertension. There was no history of diabetes, myocardial infarction or atrial fibrillation.

Clinically, Allen’s test was positive, showing complete occlusion of the ulnar artery. Interestingly, although it was the ulnar artery that appeared occluded, the worse insult appeared to the index finger.
An angiogram of the left hand showed a stenotic lesion of the ulnar artery at the level of the hook of the hamate. Radiology also revealed a hypoplastic superficial palmar arch with concomitant vessel tortuosity and truncation of the digital arteries (Figure 2). There was no response to the papaverine injection.

Before this consultation, the patient was seen by a vascular surgeon who prescribed acetylsalicylic acid (325 mg daily), vitamin E, pentoxifylline (400 mg tid) and amlodipine (5 mg daily), all for a duration of three weeks. Upon completion of this regimen, the patient’s pain did not subside and there was no improvement in the discolouration of his fingers. The vascular surgeon offered a very pessimistic prognosis to the patient, recommending amputation of the painful digits.

Surgery was performed by the senior author (Dr A Thoma) at St Joseph’s Hospital, Hamilton, Ontario. The patient underwent resection of a 2 cm segment of completely thrombotic left ulnar artery, slightly distal to the level of the hamate (Figures 3, 4). As flow from the ulnar artery was extremely sluggish, a 2 mm catheter was inserted 20 cm proximally to dilate it and achieve pulsatile flow. The artery was resected distally until open lumen was identified in the superficial palmar arch. A 2 cm vein graft from the dorsum of the foot was then harvested in a Y-shaped proximal branching pattern, which allowed a proximal anastomosis to the ulnar artery. Distally, one of the limbs of the vein graft was anastomosed to the superficial palmar arch and the second to the common digital arteries of the ring and little fingers. The distal stumps of these vessels were diseased, with obvious hypertrophy of the vessel walls. Less than ideal lumen was found to perform the anastomosis. Because of the diffuse nature of the disease, further resection of the digital arteries was not necessary.

A palmar digital sympathectomy was also performed in which the adventitia from the common digital arteries in the palm were stripped to the level of the proper digital arteries in the web spaces. During the circumferential stripping of the adventitia, the vessels looked abnormal, having a tortuous appearance with hypertrophic walls.

The histological examination of the resected ulnar artery segment and superficial palmar arch showed patchy destruction of the internal elastic lamina along with marked fibroelastic intimal thickening and narrowing of the lumen (Figure 5). An inflammatory cell infiltrate was noted within the fibrointimal tissue that consisted of numerous eosinophils mixed with mononuclear inflammatory cells and fibrin. Microscopically, giant cells and other histological features of Beurger’s disease were not present. Scattered hemosiderenladen macrophages were present in the vessel wall, suggesting previous hemorrhage. It is likely that this hemorrhage was related to the vasospasm that occurred during cold injury.

Postoperatively, Allen’s test showed good perfusion to the hand via the reconstructed ulnar artery. In addition, Doppler pulses were obtained at the base of each digit, which were not possible preoperatively. The pain caused by ische-
mia disappeared immediately after the surgery, and the ulcer completely healed within three weeks (Figure 6). Since his last follow-up at over one year after surgery, the patient remains symptom-free, has returned to his job and is functioning as he did before his injury.

**DISCUSSION**

Frostbite occurs when skin and subcutaneous tissues are exposed to temperatures of less than 2°C for variable lengths of time (1). Frostbitten skin exhibits markedly dilated and blood-filled capillaries in the superficial dermis, which is often associated with edema. Depending on the severity and rapidity of the hypothermic insult, direct tissue injury, as well as vasoconstriction, may occur. Over time, this is associated with sludging, thrombosis and fibromuscular obliteration of the vascular lumen with duplication of vessel wall components such as the internal elastic lamina (2). The effect is stenosis and occlusion of blood vessels, resulting in ischemic necrosis of tissues.

In addition to the ischemic effects related to vascular pathology in frostbite patients, there is often neuromuscular injury causing other sequelae. Patients frequently develop cold sensitivity, hyperhidrosis and intrinsic muscle atrophy. The development of arthritis, hyperesthesias, chronic pain and vasospastic attacks is not uncommon. Vasospasm is particularly detrimental in ischemic injury because it promotes further stenosis of blood vessels, greatly increasing the risk of anoxia and tissue necrosis. Consequently, in frostbite, as with crush injury and some connective tissue disorders, the microcirculation is so widely affected by pathological changes that vascular reconstruction by itself is not adequate to treat the severe ischemia (2).

For over thirty years, cervicothoracic sympathectomy was common therapy if nonoperative management of chronic vasospastic digital symptoms failed. Some symptoms treated by sympathectomy included the Raynaud’s phenomenon, hyperhidrosis in the hand and chronic hand pain, all with reasonable results. However, this procedure has provided only transient benefit, and long term results of sympathectomy performed in the proximal part of the upper limb are gener-
ally discouraging. This may be attributed to incomplete
denervation, regeneration of autonomic nerve fibres and activa-
tion of alternative pathways (3). It was also shown that
sympathectomy is relatively more successful for hyperhidro-
sis than for the alleviation of vascular disease.

In 1980, Flatt (4) suggested the use of a distal interruption of
the periarterial sympathetic fibers and digital nerve branches to
the common and proper digital arteries to control symptoms of
digital vascular insufficiency. This ‘peripheral’ sympathectomy
has provided significant palliation to patients with frostbite,
crush injuries, scleroderma and Raynaud’s disease.

Autonomic innervation of blood vessels consists of sym-
pathetic axons, which are located around the external perime-
ter of arteries. These fibres are contained only within the
adventitia and do not penetrate the media. As such, periph-
eral sympathectomy is performed by isolating the terminal
branches of the sympathetic nerves, dividing these branches
and stripping the adventitia from the appropriate digital ar-
teries. Care must be exerted when stripping adventitia so as not
to perforate the digital artery (5).

Arterial occlusive disease induces a vasomotor dis-
turbance that exacerbates ischaemia and vasospasm downstream
(6). The theoretical basis of peripheral sympathectomy is to
reduce the release of norepinephrine at the myoneural junc-
tion in the vessel wall, thereby eliminating vasospasm and di-
lating arterial smooth muscle (7).

Peripheral sympathectomy has two major advantages over
proximal cervicothoracic sympathectomy. First, it eliminates
sympathetic fibres that bypass the sympathetic trunk. In addi-
tion, the effect has been shown to last longer and is often effec-
tive when central or cervicothoracic sympathectomy has failed
(5,7). The clinical improvement in pain and cold intolerance,
and the healing of previously recalcitrant digital ulcers fol-
lowing this surgery are thought to be the result of improve-
ment in nutritional microcirculatory flow (7).

In situations, such as ulnar artery thrombosis where there
is adequate collateral circulation, excision and ligation of
the thrombosed or diseased arterial segment may be effec-
tive to interrupt the vasomotor disturbance distally (6). If,
however, collateral flow is inadequate, or if there are multi-
ple levels of occlusion, re-establishing arterial inflow by re-
construction and restoration of the arterial anatomy is preferred (8). Even very long vein grafts with multiple
branching to the palmar arch and common digital arteries are possible (9).

In the present case, frostbite-induced vascular change that
is normally isolated to the microvasculature, was shown to
involve a larger vessel, namely the ulnar artery. Reconstruction
of the superficial palmar arch was performed using a re-
verse interposition vein graft with an end-to-end anastomosis
to the distal ulnar artery and end-to-side anastomoses to the
common digital arteries. This was done with the hope of in-
creasing the inflow pressure to the digits and, thereby, im-
proving the perfusion of the involved digits. The patient
reported short term relief from acute digital pain, demon-
strated healing of the ulcer, and no longer showed signs of
Raynaud’s disease, even after one year follow-up. This cor-
relates well with peripherally sympathectomized patients de-
scribed in the literature who have also shown reduction in the
severity of cold intolerance (5,7,10).

Reconstruction of an occluded vessel and peripheral
sympathectomy have been shown to increase total blood
flow, relieve symptoms and to improve hand function (11).
Combining these two procedures in difficult to manage
cases of severe cold-induced ischemic injury to the hand is
recommended.

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