Infrapopliteal Bifurcated Dual Run-off Bypass in Critical Limb Ischemia: A Report of 2 Cases

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Recently, angiosome-oriented direct revascularization was advocated for infrapopliteal bypass in patients with critical limb ischemia. However, angiosome-matched target vessels, which supply direct blood flow into the ischemic tissue, are frequently small in diameter, severely calcified, have a very poor vascular bed, and might not be suitable technically for distal anastomosis. In such cases, creating a bifurcation in the graft could enable perfusion of a ''direct'' target vessel with poor quality and an ''indirect'' run-off vessel with better features. In this report, we present 2 cases of bifurcated dual run-off bypass (BDRB) in which we added a secondary outflow to the original single tibial bypass. Careful investigation and evaluation of the status of the collateral vessels and additional information regarding successful and unsuccessful cases are required to further understand the advantages and disadvantages of BDRB.

The angiosome concept defines specific blockages of soft tissue and skin that are supplied by distinct source arteries. Recently, this concept has been used widely for the purpose of foot revascularization in patients with critical limb ischemia (CLI).[1,2] The key benefit of the angiosome-based approach is that it divides areas of ischemic tissue loss into angiosomes and selects the angiosome-matched vessels for revascularization.[3] This could potentially provide optimal conditions for wound healing and limb salvage.

Infrapopliteal or pedal bypass is an established technique for limb salvage in CLI. The selection of run-off vessels is generally based on the ''best vessel'' approach. Less-calcified larger diameter vessels with good run-off are favored because anastomosis is technically easier and good patency is guaranteed. However, a dilemma arises when the ''best vessel'' is not matched to the angiosome with ischemic tissue loss. In such cases, adding a bifurcation in the graft can enable the perfusion of more than one angiosome. Here, we present 2 cases of bifurcated dual run-off bypass (BDRB), in which we added a secondary outflow to the original single tibial bypass. All the patients who appeared in this case report were consented to the publication.

CASE REPORT

Case 1

A 62-year-old man presented with a 2-month history of ischemic gangrene in the left fifth toe. He had suffered previously from atrial fibrillation and valvular heart disease and had undergone aortic valve and mitral valve replacement. He had been dialysis dependent for 6 years. Using a nonreversed, great saphenous vein graft, a sequential bypass which has the popliteal and tibial outflow was performed. Construction of the proximal anastomosis at the common femoral artery provided inflow of the entire bypass. The midpoint anastomosis was constructed at below-the-knee popliteal artery. Then, an aperture was opened on the graft near the midpoint anastomosis, and another vein graft was anastomosed as a side branch so that the graft went beyond the popliteal artery to the last distal anastomosis, located at anterior tibial artery. The sequential bypass was intended to perfuse both popliteal

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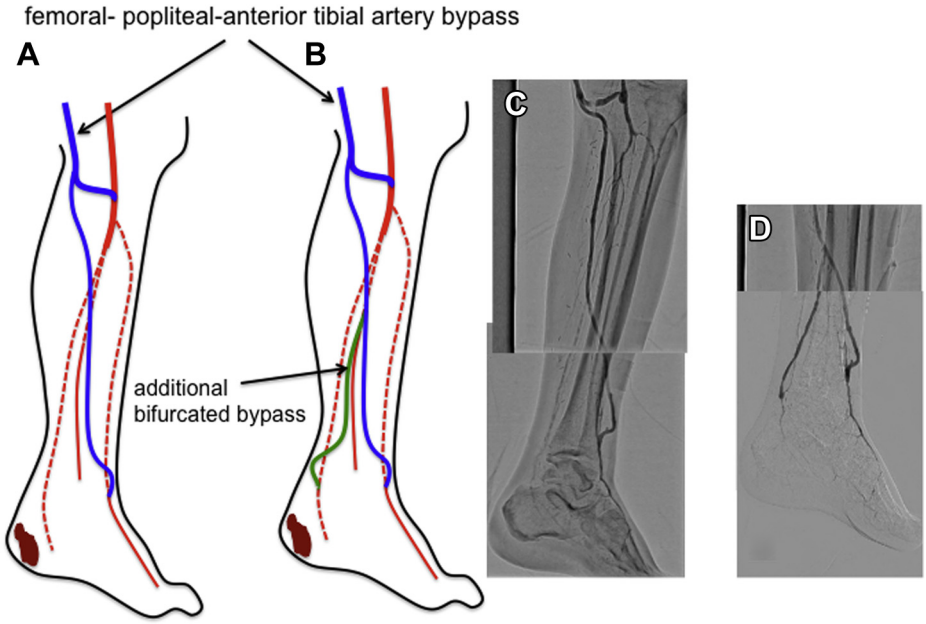

Fig. 1. Schematic representation of the primary revascularization **(A)** and the additional bifurcated bypass **(B)** in case 1. The additional bifurcated bypass to the posterior tibial artery was constructed using an autologous arm vein graft. Angiograms before **(C)** and after **(D)** the additional bifurcated bypass demonstrate the patent primary bypass and ''occult run-off'' posterior tibial artery, which could not be visualized via collateral vessels from a single primary run-off bypass **(C)** but were perfused successfully with BDRB **(D)**.

and paramalleolar segment, when the popliteal segment was isolated by multiple disease in superficial femoral artery and tibial artery. The popliteal outflow also provides better perfusion of tibial vessels other than target anterior tibial artery. And, it may prevent from the entire bypass occlusion when the tibial segment of bypass was failed. The fifth toe was amputated. The amputated stump healed in 4 weeks. Two years after the first bypass, the patient developed an ischemic ulcer on his left heel. The bypass graft was patent, and the ankle-brachial index (ABI) was 0.90 (104/116 mm Hg). Skin perfusion pressure (SPP) could not be measured because of the pain. Despite every effort to relieve the pressure and apply appropriate medication, wound care, and debridement for 1 month, the heel ulcer deteriorated. Endovascular treatment targeting the posterior tibial or peroneal artery through femoropopliteal bypass was attempted but was not successful because the guidewire could not pass the diffusely stenosed lesion. A bifurcated bypass to the posterior tibial artery was constructed by opening an aperture on the existing femoroanterior tibial artery bypass at a point located in the midcalf, and an additional graft was anastomosed to the aperture. This functioned as an inflow (proximal anastomosis) of the additional bypass. The graft was then anastomosed to the posterior tibial artery (Fig. 1). The patency of the target posterior tibial artery was confirmed by a preoperative duplex scan, as well as intraoperative direct puncture and contrast arteriography. The postoperative course was uneventful. His postoperative ABI was 1.03 (148/143 mm Hg) and SPP was 40 mm Hg in the dorsal region and 40 mm Hg in the plantar region. The heel ulcer was treated with negative pressure wound therapy and had healed completely on follow-up 3 months after the additional bypass (Fig. 2).

Case 2

A 64-year-old man presented with gangrene of the left fourth toe. He had a history of diabetes mellitus and coronary bypass and had been dialysis dependent for 6 years. The gangrenous toe was treated with minor amputation and open drainage of the plantar region. Two years later, the patient developed an ischemic ulcer over the left first to third toes. The ABI of the left limb could not be measured because of a flat pressure waveform. The SPP in the foot was 15 mm Hg in the dorsal region and 20 mm Hg in the plantar region. A sequential bypass from the left femoral artery to below-the-knee popliteal artery and the peroneal artery with a nonreversed, great saphenous vein graft was performed, similar to that described for case 1. Although the bypass was successful, pain at rest persisted and the ischemic gangrene of the toes worsened. Although his ABI improved to 0.94 (109/116 mm Hg), the SPP in the foot did not improve significantly (25 mm Hg in the dorsal region and 29 mm Hg in the plantar region). Two weeks later, a bifurcated bypass to the dorsal pedal artery was constructed by anastomosing a short saphenous vein graft to the existing bypass graft in the midcalf and to the dorsal pedal artery,