Axillobipopliteal Bypass in the Presence of Critical Limb-Threatening Ischemia

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Abstract
Axillobipopliteal bypass is a very uncommon but sometimes necessary procedure as a final attempt at revascularization for limb salvage. We present a case of extensive bilateral arterial occlusion managed by artificial grafting, with the additional challenge of an inaccessible sub-clavian artery on the left side secondary to pacemaker implantation. The proposed staged bilateral axillobipopliteal bypass was altered to supply both popliteal arteries utilizing the right sub-clavian artery alone. This procedure resulted in a restoration of blood flow, which continues to remain robust at more than three months post operatively.

Introduction
The goal of extra-anatomic bypass surgery is to achieve revascularization using remote subcutaneous pathways that can be performed with lower morbidity and mortality. This has been performed for complex vascular pathologies, including graft infection, claudication, rest pain and skin necrosis. Blaisdell and Hall introduced the axillobipopliteal bypass in 1963 [1]. Smith et al and Veith et al. [2,3] are credited with first describing the axillobipopliteal bypass in the late 1970s. In 1989, Ascet al. [4] reported a 5 year limb salvage rate of 58% following axillobipopliteal bypass. However, a thorough literature search revealed only two publications regarding the axillobipopliteal bypass [5,6]. This report presents our case of the unique and inventive axillobipopliteal bypass.

Case Report
A 77 year-old male with complex co-morbidities, including diabetes mellitus, chronic obstructive pulmonary disease, chronic kidney disease, coronary artery disease, congestive heart failure, and pacemaker insertion for 3rd degree AV block was referred by his physician for a workup of ischemia and gangrenous pedal lesions. The patient was a heavy smoker who recently quit. Physical exam revealed severe rest pain with non-palpable femoral, popliteal, and pedal pulses bilaterally. There was also dry necrosis of the left hallux and anterior ankle, as well as his bilateral heels. Bilateral radial pulses were palpable. Non-invasive vascular studies revealed an Ankle-Brachial index of 0.09 and 0.4 on the left and right, respectively, with significant proximal and mid-vascular disease. Upon admission, he was optimized prior to angiography and cardiology, pulmonology, and nephrology. Angiography revealed diffuse severe calcific disease without significant stenosis in the abdominal aorta and both common iliac arteries. The internal iliac arteries were patent. However, there was chronic total occlusion of bilateral external iliac, common femoral, superficial femoral, and above knee popliteal arteries with below knee reconstitution and two vessel infrapopliteal arterial outflow bilaterally via anterior tibial and peroneal arteries. Angiographic intervention was attempted by interventional radiology, however unsuccessful (Figure 1).

Following administration of general anesthesia, the patient’s right neck, chest, abdomen, bilateral groins, and legs were prepared and draped. An incision was made in the right sub-clavicular area, where the axillary artery was then isolated circumferentially. An incision was made along the medial aspects of the left and right calves. After reflecting the gastrocnemius posteriorly, the neurovascular bundle was identified and popliteal arteries isolated. Nine counter incisions were made in total in the right chest wall, abdomen, and upper legs in order to tunnel the bypass grafts. The 8 mm Polytetrafluoroethylene (PTFE) axillobifemoral bypass graft was tunneled using these counter incisions. Prior to any clamping, 7500 units of heparin were given systemically, and 1000 units of heparin were given every hour. After heparinization, proximal and distal clamps were placed on the right axillosub-clavian artery. An arteriotomy was performed with anastomosis of the graft to the axillary artery was then isolated circumferentially. An incision was made along the medial aspects of the left and right calves. After reflecting the gastrocnemius posteriorly, the neurovascular bundle was identified and popliteal arteries isolated. Nine counter incisions were made in total in the right chest wall, abdomen, and upper legs in order to tunnel the bypass grafts. The 8 mm Polytetrafluoroethylene (PTFE) axillobifemoral bypass graft was tunneled using these counter incisions. Prior to any clamping, 7500 units of heparin were given systemically, and 1000 units of heparin were given every hour. After heparinization, proximal and distal clamps were placed on the right axillosub-clavian artery. An arteriotomy was performed with anastomosis of the graft to the axillary artery. The PTFE graft was flushed and clamped. The ends of the axillobifemoral graft were brought out through the proximal thigh since there weren’t femoral arteries to anastomose the grafts to. A second PTFE graft, a PROPATEN 6 mm, was cut in half to provide the extra length necessary on each limb to extend to the below-knee popliteal artery. The left popliteal artery anastomosis was carried out first. The PTFE graft was cut to conform to the anastomosis and sutured in place using 6-0 GORE-TEX suture. All clamps were released and the graft was back-bled, flushed, and passed through the tunnel between the gastrocnemius heads and out the thigh.

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incision in the upper limb. A graft-to-graft anastomosis was then made by grooming both ends of the graft in a spatulated fashion and sewing them together using 5-0 Gore-TEX suture. Defects in all suture line were repaired with 6-0 prolene. All clamps were released from the left leg, revealing excellent pulsatile flow into the dorsalis pedis artery with palpable pulse. Attention was then directed to the right leg, where the same procedure was performed with the other half of the PROPATEN graft (Figure 2). Once the grafts were adequately sewn, all clamps were removed. Excellent pulsatile flow was present through both grafts, and bilateral dorsalis pedis pulses were palpable. The heparin was reversed with 50 mg of protamine and the incisions were closed with 2-0 vicryl and staples. Postoperatively the patient was started on Flavix and aspirin, however after the first postoperative day Clopidogrel was discontinued and the patient began a heparin bridge to Coumadin.

**Discussion**

Peripheral arterial disease is a manifestation of generalized atherosclerosis in the non-cardiac vessels, affecting 12-20% of patients older than age 65 in the United States [7,8]. The iliac and femoral arteries are often affected in patients with symptomatic occlusive disease and since the early 1960s extra-anatomic bypass has been performed for arterial reconstruction [1].

Although conditions requiring an axillopopliteal graft technique are rare, and those requiring axillofemoral bypass even more infrequent, the technique is useful when other avenues for limb salvage have been exhausted, which was the circumstance in our case. Concern for graft infection provided quite an uneasy feeling considering the extent of material used, however we felt it was justifiable risk allowing restoration of arterial flow. Long grafts are a technical challenge, and unfortunately large cross-sectional studies on outcomes are few. Ascero et al. [4] performed one of the largest studies, of which he reported a sole procedure from a single axillary artery origin. Originally, we had planned for a staged bilateral axillopopliteal bypass in which we would revascularize the left extremity first, as it was the most symptomatic. However, the positioning of the patient's pacemaker generator made conducting two axillopopliteal grafts impractical. The decision to graft to both extremities simultaneously rather than as a staged revascularization minimized a critically ill patient's anesthesia exposure and provided symptomatic relief to both extremities quickly. To date, the patient has had a rather uneventful postoperative course with complete alleviation of rest pain and no post-operative infections. The patient did require digital amputation of an unchanged gangrenous toe, which was present pre-operatively, but has healed. Although the necrotic areas of the heels have not completely resolved, they have improved significantly, and most importantly there are still strong palpable dorsalis pedis pulses bilaterally. Use of a commercial femoropopliteal graft limited the amount of customization necessary. One graft-to-graft anastomosis on each end provided sufficient length to reach the popliteal artery. This new use of materials combined with established technique is a treatment option for advanced bilateral peripheral arterial disease not amenable to other interventions.

**References**