Clinical Study

Technical Improvement in Tibial Bypass Surgery: Non-Dissection Method with the Tourniquet Occlusion Technique

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Abstract: We have used the non-dissection method for tibial artery bypass surgery since 1992 to improve outcomes in small artery bypass surgery. An Esmarch’s rubber bandage or a sequential pneumatic tourniquet was used in combination with an air tourniquet for arterial clamping. A total of 74 tibial bypasses were performed in 66 patients for lower extremity ischemia. Over a mean follow-up of 27.7 months, there were 14 graft occlusions or stenoses. One aneurysm was also noted. The cumulative primary patency rates were 89.5 % at 1 year, 72.8 % at 3 years, and 63.4 % at 5 years. A total of 6 grafts were revised; 2 of which became re-occluded. The cumulative secondary patency rates were 89.6 % at 1 year, 83.4 % at 3 years and 73.8 % at 5 years. Before 1992, the tibial bypass surgeries were performed with regular vascular clamps, resulting in poor patency rates (64.7 % at 1 year). The tourniquet occlusion technique appears to prevent anastomotic intimal hyperplasia. The non-dissection method is useful to achieve an acceptable outcome in tibial bypass surgery.

Key words: arteriosclerosis obliterans, thromboangiitis obliterans, tibial artery bypass, non-dissection method

INTRODUCTION

Arteriosclerosis obliterans (ASO) is now more common in Japan because of the increase in size of the elderly population1). Patients with ASO typically have diffuse disease and severe symptoms such as ulcer or gangrene, with intolerable rest pain. Arterial reconstruction is the treatment of choice for limb salvage2). Tibial artery bypass is frequently necessary in these patients. Therefore, a reasonable long-term patency rate for small artery bypass surgery is mandatory. Before 1992, the tibial bypass surgeries were performed with regular vascular clamps in our department. Unfortunately, the patency rates were unacceptably poor; 64.7 % at 1 year. We have used the non-dissection method to improve the results of small artery bypass surgery since 1992. The results of tibial bypass surgery using this improved technique were analyzed retrospectively.

METHODS

Proximal arterial anastomosis was carried out in the usual fashion employing metal vascular clamps. The tourniquet occlusion technique was used for the distal anastomosis. Before 1995, an Esmarch’s rubber bandage was used for exsanguination (Fig. 1A). The bandage was wound tightly from the toe to the thigh, an air tourniquet used proximally, and then the bandage was removed. We developed a sequential pneumatic tourniquet for automatic arterial clamping, which was used after 1995. Seven pneumatic bags arranged in parallel were inflat-
face of the artery was identified, and a marking suture was placed. After the anastomotic portion of the vein graft was marked, the limb was exsanguinated with the pneumatic tourniquet or roll manchette. The distal anastomosis was performed thereafter.

**Materials**

Since 1992, 74 tibial bypasses were performed using autogenous vein grafts in 66 patients. There were 58 men and 8 women with a mean age of 62.3 years (range: 25 to 84 years). The operative indications were disabling intermittent claudication \( n = 22, 29.7\% \), intolerable rest pain \( n = 12, 16.2\% \), and a nonhealing ulcer or gangrene \( n = 40, 54.1\% \). The etiology of arterial occlusion was ASO \( n = 50, 67.6\% \), thromboangiitis obliterans \( n = 6, 8.1\% \), chronic embolism \( n = 12, 16.2\% \), popliteal aneurysm \( n = 2, 2.7\% \), polyarteritis nodosa \( n = 2, 2.7\% \), trauma \( n = 1, 1.4\% \), and entrapment syndrome \( n = 1, 1.4\% \). The proximal anastomosis was performed to the femoral artery \( n = 33, 44.6\% \), the popliteal artery \( n = 37, 50.0\% \), the tibioperoneal trunk \( n = 2, 2.7\% \), the sciatic artery \( n = 1, 1.4\% \), or an inflow graft \( n = 1, 1.4\% \). The distal anastomosis was performed to the tibioperoneal trunk \( n = 6, 8.1\% \), the posterior tibial artery \( n = 25, 33.8\% \), the anterior tibial artery \( n = 14, 18.9\% \), the peroneal artery \( n = 23, 31.1\% \), the sural artery \( n = 1, 1.4\% \), the plantar artery \( n = 3, 4.1\% \), or the dorsal pedis artery \( n = 2, 2.7\% \). Anastomoses above the mid-thigh were performed with metal vascular clamps. Anastomoses below the mid-thigh were performed using the non-dissection method.
RESULTS

The mean follow-up period was 27.7 months (range: 1 to 85 months). There were 5 hospital deaths (7.6%). Death from prosthetic graft infection, which had been performed for inflow reconstruction, occurred in 3 patients, including 2 with diabetic nephropathy requiring hemodialysis. One patient (age: 84 years) died of an intraoperative cerebral infarction. One patient with diabetes mellitus died of an acute myocardial infarction on the 94th postoperative day. The overall cumulative survival rates were 81.3% at 1 year, 65.4% at 3 years, and 54.2% at 5 years (Fig. 2).

Over the follow-up period, there were 12 graft occlusions, 2 graft stenoses, and 1 graft aneurysm. These graft malfunctions were due to technical problems (n = 7), infection (n = 2), stenotic valve (n = 1), poor control of diabetes (n = 2), or unknown reasons (n = 2). The technical problems included anastomosis to a diseased artery (n = 2), damage to the recipient artery during anastomosis (n = 2), stenosis of the toe at the distal anastomosis (n = 2), or graft dislocation (n = 1). The cumulative primary patency rates were 89.5% at 1 year, 72.8% at 3 years, and 63.4% at 5 years (Fig. 3). A total of 6 grafts were revised, 2 of which became re-occluded. The cumulative secondary patency rates were 89.6% at 1 year, 83.4% at 3 years, and 73.8% at 5 years (Fig. 3).

DISCUSSION

Due to the growing population of elderly people in Japan, there has been an increase in the number of patients suffering from ASO. Most of these patients seen in our department are older than seventy years. The characteristic lesions of ASO have been reported to be aortoiliac and femoro-popliteal. However, in older people, the lesions are multiple and diffuse. Therefore, small artery reconstruction is often...
necessary to prevent ischemic limb loss. Severe ischemia is most commonly the result of tibial artery occlusion. A tibial or foot artery bypass is the treatment of choice for limb salvage. Thus reasonable patency rates are mandatory.

Technical considerations are more important in small artery bypass surgery than in large artery surgery. Examination of occluded grafts has revealed severe fibrosis around the anastomoses. This was likely due to operative injuries. Gama has emphasized the importance of the maintenance of nutritional circulation to prevent medial degeneration, and proposed a new concept of degenerative ischemic mediopathy. He has also suggested that circumferential dissection of the host artery with ligation of its tributaries can affect anastomotic patency. Minimizing the trauma to the native artery preserves the viability of the vessel wall and prevents anastomotic intimal hyperplasia. Therefore, the non-dissection method was adopted for small artery bypass surgery.

Before 1992, the tibial bypass surgeries were performed with regular vascular clamps in 18 limbs in our department. At that time, the patency rate at 1 year was 64.7%, including 4 early occlusions. The host artery was fully isolated and vascular spasm was frequently observed. The injury to the host artery during anastomotic procedures would be responsible for this poor outcome. Therefore, we considered that atraumatic procedures were essentially necessary for small artery bypass to achieve an acceptable outcome.

The tourniquet occlusion technique was introduced by Bernhard in 1980. We developed this technique independently using an Esmarch’s rubber bandage. Both techniques preserve the vasa vasorum of the artery and the muscular branches around the anastomosis. The bloodless field also makes anastomosis easier to perform. Furthermore, clamps do not clot-
ter the operative field. We have used this technique for below-knee procedures since 1992.

In this study there were 15 graft malfunctions. However, anastomotic intimal hyperplasia was not observed in these grafts. Instead, natural enlargement of the anastomosed artery due to an increase in blood flow was noted. The anastomotic problem was considered to be a main reason for declining long-term patency rates. Based on our observations, anastomotic intimal hyperplasia may be prevented by the non-dissection method. As Gama has reported, preservation of the structure and function of the arterial wall may improve the results of bypass surgery. Minimizing the trauma to the native artery and maintaining the nutrient flow to the arterial wall through the adventitia are keys to maintaining arterial function. Technical improvements in the non-dissection method should result in even better outcomes.

Of the graft malfunctions, 7 occurred due to a technical error. To prevent these errors, a sufficiently long segment of vein graft should be prepared, especially when the graft diameter is small. A short graft exhibits a tendency to twist easily at the anastomotic heel. When a reversed vein graft is used, the heel of the proximal anastomosis is small. A branch is used for the heel bite to prevent stenosis, as previously reported. The identification of an appropriate artery for anastomosis is also critical. A patent artery on preoperative angiography may exhibit intimal damage at arteriotomy. This is suggestive of recanalization of an occluded artery. In Buerger’s disease, recanalization is frequently observed. Small artery bypass surgery is dependent on the selection of a disease-free artery for anastomosis. In conclusion, the tourniquet occlusion technique and non-dissection method can be used to improve the results of small artery bypass surgery.

REFERENCES