

Review Article

Infrapopliteal Surgical and Endovascular Intervention

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Infrapopliteal revascularization is generally performed for patients with chronic limb-threatening ischemia. As with revascularization in other fields, the indications for endovascular treatment (EVT) have expanded in recent years due to advances in endovascular devices and techniques. However, the optimal revascularization method must be selected based on (1) patient risk, (2) limb severity, and (3) anatomical pattern of disease. Therefore, vascular surgeons need to understand the characteristics of EVT and surgical treatment and improve their technical skills in both procedures. Here is an overview of the current methods of revascularization. (This is a translation of Jpn J Vasc Surg 2024; 33: 61–65)

Keywords: chronic limb-threatening ischemia, bypass surgery, endovascular treatment, hybrid treatment

Introduction

In this article, we describe revascularization in the lesion of the infrapopliteal artery. The JCS/JSVS 2022 Guideline on the Management of Peripheral Arterial Disease of the Japanese Circulation Society/Japan Society of Vascular Surgery recommends infrapopliteal angioplasty and bypass surgery with artificial graft for claudication should not be performed (classified as Class III).¹⁾ Therefore, a revascularization procedure is generally performed for chronic limb-threatening ischemia (CLTI). The percentage

of patients with CLTI with diabetes mellitus and dialysis patients in Japan is higher than that in other countries, exceeding 70% and 50%, respectively (SPINACH registry).²⁾ In these cases, the infrapopliteal lesion is often responsible for progression of disease, and it is necessary to perform revascularization in this area. However, in actual clinical practice, revascularization itself is often challenging due to severe calcification, frequent long-segment occlusive disease, small vessel diameter, and poor runoff. Therefore, preoperative planning is very important.

The following is an overview of the revascularization of the infrapopliteal artery lesion.

I. Surgical Treatment

1. Determination of proximal target artery

1.1 Ensuring a sufficient blood flow as inflow

The proximal anastomosis should be selected in the most distal artery without proximal stenotic lesion, specifically, it should be palpable proximally to the artery responsible for the ischemia. A previous report indicates that there is no problem if the arterial pressure is measured and the difference from the upper limb blood pressure is 10 mmHg or less.³⁾ In addition to the common femoral artery, the superficial femoral artery, deep femoral artery, popliteal artery, or rarely, the crural artery may be used as sites for proximal anastomosis site (Fig. 1).

1.2 Less likely to develop stenosis in the future

It is known that the patency rate is better with anastomosis to native artery anastomosis than to an artificial graft; thus, proximal anastomosis at the artificial graft should be avoided if possible.⁴⁾

2. Determination of distal target artery


The distal anastomosis site is determined based on the clinical symptoms. In the case of resting pain, hemodynamical improvement of inflow artery may improve clinical symptoms, but in the case of gangrene, improvement in inflow alone often does not achieve wound healing after gangrene amputation. Basically, distal target is selected to be the most proximal limb artery that has at least one continuous runoff artery to the ischemic wounds. In general, a less calcified and

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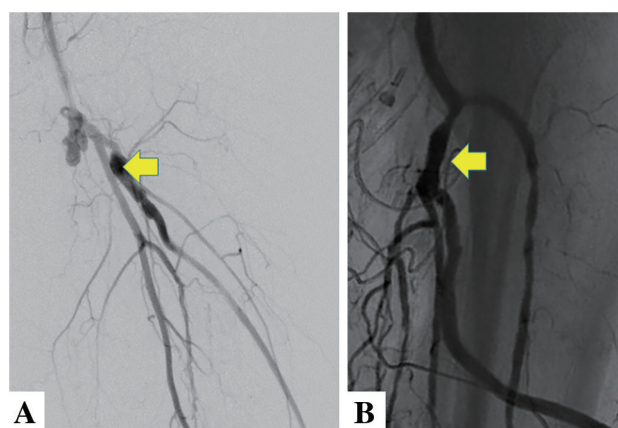


Fig. 1 Inflow site of distal bypass. (A) Deep femoral artery. (B) Tibioperoneal trunk.

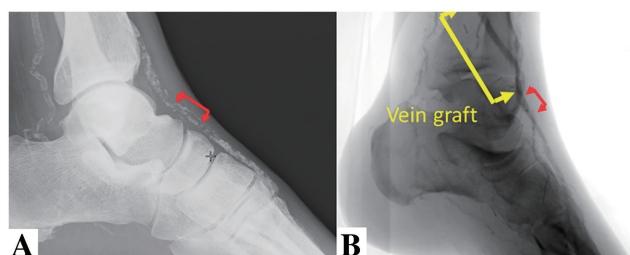


Fig. 2 Outflow site of distal bypass. (A) Plain X-p revealed severe calcification of the dorsal pedal artery. There was slightly less calcification part near the ankle joint (red arrow). (B) The site with relatively low calcification was selected as the distal anastomosis site (red arrow). The yellow arrow indicates the vein graft.

better runoff artery is selected. There is still room for debate as to how to incorporate angiosome concept into the selection of distal anastomosis sites.¹⁾

In addition, diabetes mellitus and dialysis patients often have severe calcification. We preoperatively take X-rays of the lower extremities to determine the extent and degree of arterial calcification. Ultrasound examination is also performed to evaluate the extent of calcification. When selecting distal anastomosis, calcifications should be avoided as much as possible, especially at the heel and toe of anastomosis (Fig. 2).

3. Conduits in distal bypass

The use of an autologous vein is strongly recommended for distal bypass surgery. The great saphenous vein (GSV) is the most preferred vein, but the small saphenous vein and the arm vein are also options. If one vein is insufficient, two or more veins are combined (spliced vein graft).

It is necessary to evaluate the diameter of the above-mentioned veins and the presence or absence of inflammation by using duplex US preoperatively (vein mapping).

The autogenous graft configurations include the reversed manner, the non-reversed manner, and the *in situ* manner. The latter two manners are preferred when there are large differences in caliber between the anastomotic artery and vein graft. A subanalysis of randomized controlled trials (RCTs) showed no significant difference in patency rates between reverse and non-reversed methods, but spliced vein/arm vein and single GSV use, graft diameter, and graft length were associated with patency rates.⁵⁾

4. Inframalleolar bypass

Bypass to the dorsalis pedis artery has been widely reported and is a standard surgical procedure.^{6,7)} However, in daily clinical practice, dorsal pedis artery or common plantar artery are sometimes occluded, and this is often considered a “no-option.”⁸⁾ The definition of “no-option” is difficult. Since pedal branch artery bypass are sometimes performed at some institutions, I think that this case cannot be considered a “no-option” from the point of anatomical features. It has been reported that wound healing in pedal artery bypass and pedal branch artery bypass did not differ between the two groups.⁹⁾

II. Endovascular Therapy

Unlike the femoropopliteal lesion, treatment in infrapopliteal lesion is currently limited to plain old balloon angioplasty (Fig. 3). After detailed angiography, it is basically selected to recanalize the anatomically least technically challenging vessel. It has been reported that angiosome-based EVT resulted in good wound healing in cases involving ischemic wounds.¹⁰⁾

The antegrade approach sometimes does not provide sufficient procedural success, and retrograde distal puncture is often performed. However, most puncture sites coincide with the distal target site of bypass surgery, so clinicians must consider, when selecting the puncture site, to avoid the possibility of bypass conversion. Recent advances in devices and these techniques have improved the initial technical success rate, but some cases are still unsuccessful. Morphologically, it was reported that (1) whether the distal true lumen was visible, (2) lesion length, (3) vessel diameter, (4) presence of calcification at the proximal end of the occlusion, and (5) entry shape were associated with successful guidewire passage.¹¹⁾

There is no consensus on the efficacy of EVT on inframalleolar arteries. There are reports that below the ankle angioplasty significantly improved the wound healing rate and wound healing period.^{12,13)} However, evidence is still lacking, and the Global Vascular Guideline (hereinafter referred to as GVG) states that it is an issue to be addressed in the future.

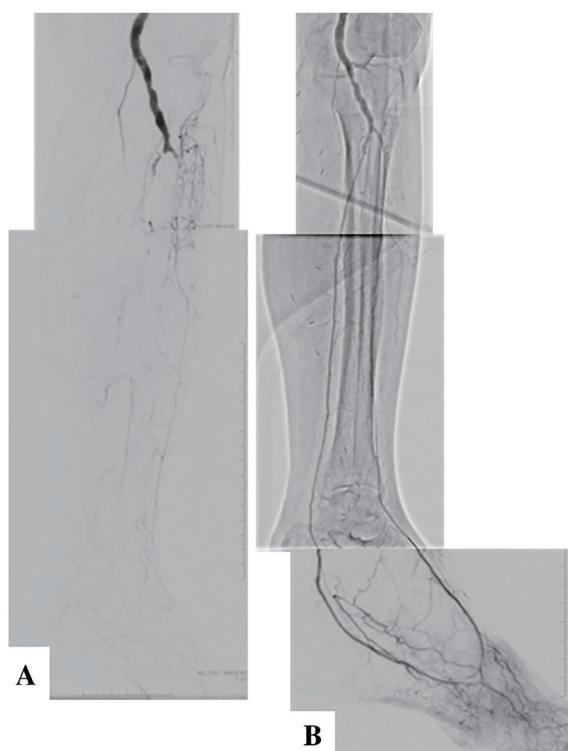


Fig. 3 Infrapopliteal angioplasty. (A) Three crural arteries were occluded with long lesions. (B) The anterior and posterior tibial arteries were revascularized after angioplasty.

III. Hybrid Therapy

Hybrid therapy is a useful treatment for revascularization in patients with multilevel disease. This leads to shorter hospital stays and fewer surgical site complications. The veins used for graft can also be shortened. When sufficient blood flow cannot be secured in the selection of the proximal target artery, inflow EVT may be performed at the same time. The hybrid procedures are classified as follows: 1. aorto-iliac EVT+infringuinal bypass, 2. femoropopliteal EVT+infrapopliteal bypass, 3. femoropopliteal bypass + infrapopliteal EVT, 4. paramalleolar/inframalleolar bypass + below the ankle EVT. In recent years, EVT of the superficial femoral artery has become widely used, and we often perform femoropopliteal EVT + inframalleolar/paramalleolar bypass from popliteal artery as the proximal anastomosis site. With advances in endovascular therapy, it is expected that clinical outcomes may change in the future, but evidence is currently lacking.

IV. Appropriate Revascularization Method (EVT or Bypass Surgery)

Regarding revascularization of the infrapopliteal lesion, both the 2017 European Vascular Surgery Guidelines¹⁴⁾ and the Japanese Guidelines¹⁾ classify bypass surgery

with autogenous vein graft as Class I and EVT as Class IIa. However, since arterial reconstruction in this lesion is performed in patients with CLTI, an optimal revascularization method is necessary to comprehensively decide based on the patient and the affected limb characteristics, the presence or absence of suitable vein for graft, and the optimal clinical endpoint.

GVG recommends the PLAN approach when deciding strategies. This concept consists of (1) patient risk, (2) limb severity, and (3) anatomical complexity of disease. However, while the usefulness of the WIfI classification is well accepted, there are still many practical issues to be solved regarding the evaluation of (1) and (3). On the other hand, SPINACH, which has been reported from Japan, provides information on determining whether bypass or EVT is preferable for each case by scoring items such as wounds, infections, anemia, and comorbidities.

Recently, a randomized trial of endovascular versus surgical treatment was reported in the United States. Major adverse limb event (MALE) or death, reintervention, and major amputation were higher for EVT group.¹⁵⁾ In addition, the results of BASIL-2, an RCT in patients with infrapopliteal disease, were reported from the UK, and the amputation-free survival was better with EVT.¹⁶⁾ At first glance, these results appear to be contradictory, and further studies are warranted. However, the proportion of patients undergoing dialysis and diabetes is higher in Japan than in Europe and the United States, and patients with CLTI are highly diverse, so it is important to select a treatment method according to each case.

Conclusion

Infrapopliteal artery revascularization is a treatment for CLTI. Therefore, ischemic wound healing, maintenance of ambulatory, and limb salvage are generally the goals of the treatment. Conversely, the patient background, affected limb background, and anatomical characteristics are often severe and complex, and it is necessary to consider the setting of clinical endpoints of the treatment and the selection of the optimal revascularization method for each patient. In addition, because most of these patients have severe calcification and small diameter vessels, the chosen revascularization method itself often requires a high degree of technical skill. It is necessary to fully understand the advantages and disadvantages of both EVT and bypass surgery, and clinicians have to gain updated information and improve technical skills.

Disclosure Statement

The author reports no conflicts of interest in relation to this article.

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