Below the knee angioplasty

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Introduction

Below the knee (BTK) angioplasty is different from other vascular interventions because occlusions are more common than stenosis and the lesions more often diffuse in BTK. The main clinical symptom of BTK intervention is critical limb ischemia rather than claudication. The clinical course of resting ischemia without aggressive treatment is very poor, as 1 year after nocturnal pain or ulceration has developed, 50% of patients either die or are amputated (1-3). BTK lesions are seen in 95% of critical limb ischemia (CLI) patients. Primary amputation rate of CLI patients is about 25%. After below knee amputation, 2nd leg amputation rate is 50% within 5 years (4). Revascularization with angioplasty can reduce major amputation rate from 59% to 8%, compared with non-revascularization (5). The aim of BTK treatment is limb salvage, preventing major amputation, and promoting wound healing.

Which artery should be treated?

In a previous report, studies showed that the best therapy for limb salvage in diabetics with CLI is to give direct flow to the foot (6). However, more recently, wound-related artery recanalization based on angiosome concept has been considered to be more important.

There are six angiosome supplied by three main arteries in the foot and ankle. Posterior tibial artery branches including the medial calcaneal, medial and lateral plantar arteries, which supply the medial ankle and the medial foot. The anterior tibial artery continues to the dorsalis pedis artery, which supplies the dorsum of the foot. The two branches of the peroneal artery, which are the anterior perforating branch and lateral calcaneal artery, supply the anterolateral ankle and the lateral rear foot. Recent publications have shown the potentially better long-term results of angiosome-guided revascularization for limb salvage, compared with non-targeted revascularization (7-9).

However, angiosome-guided revascularization is not always possible because of technical difficulties or anatomical variations. When distal runoff exists in the patent pedal artery below the ankle it should first be re-canalized. Sometimes, indirect revascularization can be successful, especially in the presence of collaterals. If there are no distal landing arteries in foot such as the dorsalis pedis or plantar arteries, failure rate is very high.
BKT angioplasty

Access routes

For BTK intervention, there are two access routes: antegrade and contralateral retrograde access. Despite its technical difficulty, ipsilateral antegrade access has many advantages. First of all, length to foot lesion is short. Therefore, there are no limitations in selecting devices. The straight course of the artery also means good pushability and tortuosity. However, puncture-related complications may be more frequent than retrograde access. Contralateral, retrograde access is familiar and safe, but only long devices can reach the lesion. There are some challenging conditions in antegrade access such as obesity, calcified plaques, SFA proximal occlusion, and considerations of clinical history of cural, hip-prosthetic surgery. In obese patients, abdominal fat can be pushed up using a sticking plaster to make antegrade puncture easy.

Guidewires and balloons

The choice of guidewire (GW) is very important for BTK intervention. For long segment occlusions, we first attempt the intraluminal approach. In recent onset occlusion, minimal calcified, or short lesion, I prefer hydrophilic wire, V18 (Boston Scientific) and Connet (Abbott Vascular) as 0.018” or Command ES (Abbott) as 0.014” GW. But calcified or late onset lesions, CTO (chronic total occlusion) wires such as Winn (Abbott), Astato (Ashai) GWs would be better. Usually, we choose lighter CTO wires first. If they do not work, we can re-attempt with a heavy CTO wire. A support catheter is sometimes necessary for intaluminal tracking because wire only or balloon catheter support is not enough in a dense calcified lesion. For subintimal angioplasty, 0.016” Glide wire (Terumo) or V18 wire are used. We prefer small profile wires because 0.035” wires make larger loops and increase the risk of vessel rupture. For short segment occlusion or stenosis, we use Winn 40 or V18 GWs. For below ankle level, 0.014” GW system is used. Usual balloon size is 3-2.5mm for tibial arteries and 2-1.5 mm for below the ankle artery. Long tapered balloon catheters may be useful for long CTO lesions. These long balloons are conically shaped (for example, proximal half is 3mm, distal half 2.5mm in diameter), adapting themselves to the vessel diameter as it changes from the knee to the ankle (diameter reduction of 0.5 mm). Sometimes cutting balloon is necessary in heavily calcified lesions or lesions resistant to conventional balloons.

Techniques for recanalization

Most interventionalists first attempt intraluminal wire passing. When crossing the soft lesion, we gently advance the hydrophilic wire. If you feel some resistance, you can pull back the wire and re-advance with different direction to advance into the micro-channel. During crossing the CTO wires in hard lesion, we can use drilling (rapid
rotation) and penetration technique (back and forth). If the intraluminal passing fails, subintimal wire passing can be performed. Its success rate is about 85% due to the thin intima of distal tibial arteries. We try to make a small loop (rotating wire and making a loop with distal soft tip), to prevent vessel rupture during subintimal angioplasty.

If the subintimal approach fails, we can perform alternative techniques. Many techniques have been introduced, including distal puncture with retrograde access, the pedal-plantar loop technique, transcollateral technique, and subintimal rendez-vous technique. Retrograde approach is effective because total occlusions that cannot be crossed from the above can easily be traversed intraluminally from the below since the distal cap of an occlusion may be softer than proximal cap. The pedal puncture was performed when we either failed to cross the wire or failed to find the arterial orifice from antegrade access. Intra-arterial nitroglycerine injection is necessary to prevent spasm. We use 21G needle and V 18 wire during pedal access. Guidewire can be captured with 4-5 F angled catheter from antegrade access. There are two methods of pedal puncture. Fluoroscopic guidance is the most widely used technique. In this case, calcification, contrast injection or road map image can be used as landmarks. On the other hand, ultrasound guidance has some advantages. There is less radiation, no need for contrast, and it is easier to avoid puncturing the surrounding veins. Hemostasis of pedal puncture site is performed with endoluminal balloon tamponade or manual compression. If not controlled, the external cuff compression at middle puncture can be used. When reentry fails during retrograde subintimal angioplasty, CTO wire sometime can be used to perforate intima or we can use double balloon technique, CART (controlled antegrade and retrograde subintimal tracking) technique, and outback reentry catheter. In my experience, CART or reverse CART technique is more convenient and effective. I recommend it as the technique of choice during the first attempt. If there is no stump of proximal tibial arteries, we cannot do CART or double balloon technique. At that time, we can use the reentry catheter. We inserted a reentry catheter from antegrade approach. And then we puncture wire loop in subintimal space from retrograde approach. And then wire can be advanced into to tibial artery.

Another alternative technique is the plantar loop technique. For plantar loop techniques, the presence of a plantar arch is essential because it is absent in 10% of cases. We use 014 wire and 1.5 mm balloon for support during this loop technique. Plantar loop is a very important structure for distal toes perfusion because metatarsal arteries come from the plantar loop. Therefore, we should be aware not to damage pedal plantar loop such by dissection or overdilation.

In heavily calcified CTO lesions, balloon catheters are sometimes not advanced over the wire, which is intraluminally located. Very low profile balloons can be selected. But if it does not cross, we can attempt the PIERCE technique (10). The calcified plaque is broken down using percutaneous direct needle puncture. This technique makes cracks
in the calcified plaque to facilitate the passage of the balloon catheter through the calcified lesion.

**Stents and Drug-coated balloon**

The role of the stent is less important in BTK intervention. Usually, stenting in BTK is not necessary except in cases of recoil, refractory stenosis or dissection. In one meta-analysis, infrapopliteal drug eluting stent therapy demonstrates the non-superiority over control therapies (bare metal stent /PTA) at 3 years, although short-term benefits at 12 months after DES therapy were evident (11).

Drug-coated balloons (DCB) can reduce neointimal hyperplasia. As a result, the reduction of restenosis and healing time can be expected, theoretically. However, many studies show DCB is not superior to standard PTA balloon alone as it lacks level-I evidence of its efficacy (12). The reasons why DCB is not superior to PTA are that BTK lesions are long occlusion with calcification and drug loss will happen from the balloon surface during the advancement in the BTK arteries.

**Conclusion**

In spite of its relatively short patency, BTK angioplasty shows good limb salvage rate, 82-91 % at 3 years. Furthermore, recent advanced technology and alternative techniques encourage higher technical success rate (13-15). In conclusion, more aggressive and advanced revascularization techniques are necessary for limb salvage. Considering the grave clinical outcomes of major amputation, BTK intervention may be a life-saving procedure like oncologic intervention for critical limb ischemia.

**Reference**

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