Temporal reverse flow by proximal femoral artery occlusion during drug-coated balloon dilatation: a technique to minimize downstream particle embolization and systemic adverse effects

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ABSTRACT
Downstream paclitaxel particle embolization for nonhealing ischemic ulcers and systemic adverse effects caused by a paclitaxel drug-coated balloon are of concern, and safety measures to prevent these adverse risks are needed. To reduce distal particle embolization and movement of the paclitaxel particles to systemic blood flow during drug-coated balloon inflation, proximal balloon occlusion using a sheathless temporary occlusion balloon-guiding catheter and extraction by manual aspiration of the paclitaxel-containing blood through the catheter are good treatment options to overcome these risks. Here, we introduce this method with tips and tricks, and demonstrate initial experience of this technique. (J Vasc Surg Cases Innov Tech 2021;7:763-7.)

Keywords: Peripheral artery disease; Critical limb ischemia; Superficial femoral artery; Drug-coated balloon; Downstream embolization

Endovascular therapy for femoropopliteal (FP) lesions has rapidly progressed due to introduction of new devices such as drug-coated balloons (DCBs), atherectomy, and drug-coated stents.1,2 The concept of “leave nothing behind” in FP lesions when using a DCB is particularly promising in endovascular treatment.3 However, downstream paclitaxel particle embolization for nonhealing ischemic ulcers4,5 and systemic adverse effects caused by a paclitaxel DCB are of concern,6,7 and safety measures to prevent these adverse risks are needed. To reduce distal emboli during DCB inflation, proximal balloon occlusion using a sheathless temporary occlusion balloon-guiding catheter (b-GC) is a good treatment option to overcome these risks.8 Here, we introduce this method with tips and tricks for treatment of FP lesions using a DCB.

METHOD

Technique. This technique is performed for patients with FP lesions treated by DCBs. First, a 6F 11 cm sheath is inserted through the ipsilateral common femoral artery to perform a diagnostic angiogram, which is useful for insertion of a sheathless guiding catheter (Fig 1, A). Immediately after recording this angiogram, a b-GC (Optimo PPI; Tokai Medical Products, Aichi, Japan) with an outer diameter equal to a 6.5F sheath is placed from the 6F sheath and advanced to just proximal of the target lesion (Fig 1, B). After successful guidewire crossing with intraluminal wire passage, predilatation is performed with an over-the-wire (OTW) balloon catheter that is compatible with a 0.035-inch guidewire (Fig 1, C and D). Just before retrieving the balloon catheter, the b-GC balloon lumen is inflated to interrupt the antegrade flow of the superficial femoral artery (SFA) (Fig 1, E). Subsequently, the popliteal artery is compressed from the body surface below the popliteal joint using a blood pressure cuff or tourniquet at a pressure of 20 mm Hg plus systolic pressure. Angiography is then performed through the OTW lumen of the predilatation balloon catheter, concomitant with simultaneous manual aspiration through the guiding catheter lumen of the b-GC. This is performed to confirm reverse flow from the popliteal artery to the proximal superficial artery (Fig 1, F). After confirming reverse flow in the target lesion, DCBs are dilated in the lesion (Fig 1, G). When deflating the DCBs, simultaneous blood aspiration through the guiding catheter lumen of the b-GC avoids distal embolization (Fig 1, H). The amount of blood obtained using this extraction was always 20 mL through the guiding lumen of the b-GC. After deflating the temporary occlusion

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Author conflict of interest: none.

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RESULT AND CLINICAL EXPERIENCE

From December 2018 to December 2019, 26 patients (36 lesions) with lower extremity peripheral artery disease underwent DCB (IN.PACT Admiral; Medtronic Inc, Dublin, Ireland) angioplasty using the above technique. The patients were aged 76 ± 7.9 years, and included 6 males (46.1%) and 8 critical limbs (61.5%). Comorbidities included diabetes (61.5%), hemodialysis (69.2%), and hypertension (69.2%). All lesions were de novo, and the mean diameter and length were 5.6 ± 0.6 mm and 112 ± 58.4 mm, respectively. All procedures were successfully performed with optimal DCB dilatation and without complications such as slow flow, no-reflow, and thrombosis. The details of the patients and preprocedure and procedure characteristics are shown in the Table.

In histologic findings, paclitaxel particles were seen in blood that was aspirated and extracted from the b-GC guiding lumen under proximal balloon occlusion just after deflating the DCB (Fig 2). A representative case of DCB angioplasty using proximal balloon occlusion is illustrated in Fig 3 and Supplementary Video, online only.

DISCUSSION

DCBs have improved the patency rate, but two major concerns about negative aspects of DCBs have also been raised recently. One is the potential risk of an embolic effect caused by the downstream release of paclitaxel. Downstream vascular damage has been observed with a DCB,4 and a clinical case of painful rash after DCB treatment has been reported.5 Thus, use of a DCB carries a risk of delayed wound healing in patients with critical limb ischemia. The second concern is the increased risk of mortality after the use of a paclitaxel-coated balloon. Since a systematic review and meta-analysis in November 2018, there has been a major debate about these concerns.7,8 The RADISH study concluded that DCB therapy did not lead to delayed wound healing; even a slow flow phenomenon after DCB was experienced.10 However, it would be better to avoid these negative aspects if it did not take excess invasion and cost. To perform this technique, it takes only
### Table. The details of the patients and preprocedure and procedure characteristics

| Item                               | Value       | Item                               | Value       | Item                               | Value       |
|------------------------------------|-------------|------------------------------------|-------------|------------------------------------|-------------|
| **Background of the patients**     |             | **Preprocedure characteristics of the patients** |             | **Details of the procedures characteristics** |             |
| Age, years                         | 78 ± 6.8    | Lesion type, % (n/N)               |             | Number of treatment DCBs per lesion, mean (N) | 1.3         |
| Male gender, % (n/N)               | 69.2 (18/26) | De novo                            | 83.3 (30/36) |                                     |             |
| Body mass index, kg/m²             | 21.0 ± 3.6  | Restenotic (nondented)             | 16.7 (6/36) | Number of treatment DCBs per leg, mean (N) | 1.8         |
| Diabetes mellitus, % (n/N)         | 53.8 (14/26) | In-stent restenosis                | 0 (0/36)    |                                     |             |
| Hypertension, % (n/N)              | 69.2 (18/26) | Target lesion, % (n/N)             |             |                                     |             |
| Hyperlipidemia, % (n/N)            | 38.7 (10/26) | Superficial femoral artery         | 80.6 (29/36) |                                     |             |
| Current smoker, % (n/N)            | 15.4 (4/26) | Popliteal artery                   | 19.4 (7/36) |                                     |             |
| Renal insufficiency, % (n/N)       | 84.6 (22/26) | Lesion length                      |             |                                     |             |
| Hemodialysis                       | 57.7 (15/26) | Mean mm ± SD                       | 112.2 ± 58.4 |                                     |             |
| Rutherford clinical category, % (n/N) | Min. Max | Diameter per balloons, mm   | 5.6 ± 0.7    |                                     |             |
| Occluded, % (n/N)                  | 13.9 (5/36)  | Paclitaxel dose, per leg µg        | 12627.9 ± 5333.2 |                                     |             |
| 3                                  | 34.6 (9/26)  | Procedural success, % (n/N)        | 100 (26/26)  |                                     |             |
| 4                                  | 26.9 (7/26)  | Access site complication, % (n/N)  | 0 (0/26)     |                                     |             |
| 5                                  | 26.9 (7/26)  | Reference vessel diameter, mean mm ± SD | 5.7 ± 0.6 | Dissection, % (n/N) |             |
| 6                                  | 11.5 (3/26)  | TASC lesion type, % (n/N)          | Grade A-C    | 96.1 (25/26)                       |             |
| ABI, per target limb               | 0.67 ± 0.35 | A                                  | 23.1 (6/26)  | Grade D-F                          | 0 (0/26)    |
|                                   |             | B                                  | 26.9 (7/26)  | Slow flow                          | 0 (0/26)    |
|                                   |             | C                                  | 46.2 (12/26) | No flow                            | 0 (0/26)    |
|                                   |             | D                                  | 3.8 (1/26)   | Popliteal artery injury by external compression | 0 (0/26)    |
|                                   |             | Below-the-knee runoff vessel       | 2 ± 0.9      |                                     |             |

*ABI: Ankle brachial index. DCB: drug-coated balloon. SD: standard deviation.
Procedural success was defined as successful drug-coated balloon angioplasty with a residual stenosis <20% without the occurrence of any major in-hospital adverse cardiovascular events. Access site complication was defined as major bleeding requiring transfusion and access site vascular injury.
Dissection was classified according to previous report.*

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an additional few minutes and approximately $300 patient charges in Japan.

The key device in our technique is the b-GC. In Japan, the Optimo PPI is available. This catheter is often used to perform carotid artery stenting. Proximal artery occlusion using a temporal balloon occlusion catheter can produce temporary reverse flow during DCB angioplasty in FP lesions. The consensus among vascular surgeons is that blood flow in the superficial artery is reversed during arteriotomy in the common femoral artery. This reverse flow and extraction of blood from the b-GC can minimize distal particle embolization during DCB inflation and thus reduce the systemic adverse effects of paclitaxel-coated balloons. Crystals of paclitaxel were detected in blood extracted from the b-GC.

In our initial approach, only proximal balloon occlusion using a b-GC was performed, without popliteal external compression. However, there are many small arteries in the distal SFA and popliteal arteries in many cases, and proximal balloon occlusion is not sufficient to produce reverse flow in the distal SFA and popliteal arteries. In such cases, there are two important tips to create reverse flow in target lesions. One is to advance the b-GC to just proximal to the target lesion, and the other is external compression on the popliteal artery just distal to the target lesion. Such external compression can increase the resistance of blood flow to the popliteal artery, which suppresses the small artery antegrade flow. With external compression at the popliteal artery only, the risk of a paclitaxel particle downstream effect on skin around the popliteal artery is greatly increased. Therefore, additional angiography through the OTW lumen is important to confirm reverse flow at the target lesion.

To perform this technique, it takes only an additional few minutes and approximately $300 patient charges in Japan.

This study was influenced by two characteristics of the Japanese health insurance system. First, the DCB used in the study (IN.PACT Admiral) was the only one available in our institution as of October 2019. Second, provisional stenting after DCB dilatation is not permitted by the health insurance system in Japan. Thus, we have to manage the dissection and vessel rupture carefully.

Limitation. This study has several limitations. One is this study is a single-center observational study including selected patients. Therefore, some specific lesions such as proximal SFA involving the common femoral artery...
were not analyzed. The other is that we could not measure the concentration of paclitaxel in the extracted blood and serum, which might strongly support the efficacy of this technique.

CONCLUSIONS
Our proximal balloon occlusion technique using a b-GC, simultaneous manual aspiration, and external compression at the distal popliteal artery may be an important treatment option for DCB angioplasty to potentially minimize risks of distal particle embolization and systemic adverse effects.

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