Direct Puncture of a Surgically-exposed Femoral Artery Graft for Simultaneous Stenting of Coronary, Carotid and Innominate Artery Stenoses

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Objective: The number of access routes for endovascular treatment is limited in patients with a history of aorto-femoral bypass surgery. Here, we present a patient with stenosis of the coronary, left carotid, and innominate arteries. We performed simultaneous stenting of each stenotic lesion by direct puncture of a femoral artery graft with surgical exposure and purse string suture ligation.

Case Presentation: The patient was a 74-year-old male with a history of aorto-bifemoral bypass surgery, coronary artery stenting, and coronary artery bypass grafting for systemic atherosclerotic disease. Coronary artery stenting became necessary because of recurring angina pectoris. The three lesions were treated simultaneously by surgical exposure and direct graft puncture and 9 Fr sheath insertion. The punctured graft was sutured for hemostasis. No puncture site complications were noted.

Conclusion: This case suggests that when the number of possible access routes for endovascular treatment is limited, it is feasible and safe to perform direct graft puncture with surgical exposure, and to achieve hemostasis by suturing the puncture site.

Keywords ▶ aorto-femoral bypass, coronary artery disease, carotid artery stenting, dacron graft, arteriosclerosis obliterans

Introduction

Patients with peripheral arterial disease (PAD) often require treatment for coronary or carotid artery stenosis. For this reason, when treatment for PAD lesions is needed, it is important to evaluate the patient for the presence of systemic atherosclerotic disease.1-3 In particular, when bypass surgery using an artificial vascular graft is performed for PAD, the surgical approach via the femoral artery for endovascular treatment may be difficult, making it necessary to choose an alternative access route. For example, a transbrachial approach and direct puncture with surgical exposure of the carotid artery have been reported when the femoral artery was difficult to puncture. However, such alternative approaches are not feasible in all patients. In some patients, the surgeon may consider graft puncture in order to secure an access route.

Some reports suggest that angiography with percutaneous puncture of a femoral artery graft may be safe.4-7 However, most of the patients involved underwent manual compression for hemostasis. Puncture site complications were frequent, including hematoma, pseudoaneurysm, infection, lower extremity ischemia, and graft rupture. For this reason, other access routes are preferred where possible.4) There have been few reports of direct graft puncture with surgical exposure, an approach that may reduce the risk of puncture site complications.8)

In this report, we present a patient with stenosis of the coronary, left carotid, and innominate arteries. Access to the brachial artery was difficult. We therefore performed simultaneous stenting of each stenotic lesion by direct puncture of a femoral artery graft with surgical exposure.
Case Presentation

Patient: A 74-year-old male.
History: The patient’s medical history included hypertension, diabetes, hyperlipidemia, smoking, osteoarthritis of the left knee and right ankle, PAD, unstable angina pectoris, retinal vein occlusion, left internal carotid artery (ICA) stenosis, innominate artery stenosis, and left subclavian artery occlusion. For treatment of lower extremity PAD, an abdominal aorta-right common femoral artery bypass using a Dacron graft (InterVascular; La Ciotat, France) had been performed 25 years prior to presentation. Abdominal aorta-left common femoral artery bypass using a Dacron graft (Hemashielf; Boston Scientific, Marlborough, MA, USA) had been performed 22 years prior to presentation. For unstable angina pectoris, the patient had undergone drug-eluting stent placement and coronary artery bypass grafting 11 years and 4 years prior to presentation. For unstable angina pectoris, the patient had undergone drug-eluting stent placement and coronary artery bypass grafting 11 years and 4 years prior to presentation. For left subclavian artery occlusion, percutaneous stenting had been attempted unsuccessfully 11 years prior to presentation. He was treated with long-term oral medication including dual-antiplatelet therapy (aspirin and clopidogrel), antidiabetic agents, and antihypertensive agents.

History of present illness: Owing to an increase in the frequency of exertional chest discomfort, coronary artery CTA was performed. This revealed severe stenosis in the left anterior descending branch (#7), to which the prior coronary artery bypass had not been anastomosed. Accordingly, re-treatment by percutaneous coronary intervention (PCI) was indicated. Because puncture of the right radial artery and brachial artery was not possible owing to multiple prior angiograms, angiography was performed via surgical cut-down of the right brachial artery. In order to provide adequate access route for PCI, it was necessary to consider either surgical exposure and cut-down of the brachial artery, or graft puncture.

Physical examination on admission: The patient was fully conscious and without motor or sensory disturbance. Decreased right visual acuity was noted due to occlusion of the retinal vein.

Imaging findings
Carotid artery ultrasound: We measured a peak systolic velocity (PSV) of 498.6 cm/sec in the left ICA, and 85.1% stenosis by North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria with acoustic shadow in some of the plaques. By comparison, 3 years prior to this procedure, left ICA PSV was 285.6 cm/sec, suggesting marked progression of stenosis. No significant stenosis was seen in the right ICA. Cervical CTA showed that the stenotic lesion of left ICA was located at the level of the 4th cervical vertebra. The study also demonstrated semi-circumferential calcification at the carotid bifurcation. No obvious anatomic anomalies of the carotid artery were observed.

MRA: We measured progression of innominate artery stenosis from 61% to 85% over the course of 5 years. Left subclavian artery stenosis was also noted. The left vertebral artery (VA) was not sufficiently delineated from its origin. No other stenotic lesions were observed apart from the left ICA (Figs. 1A and 1B).
Thoracic aortic CTA: Imaging demonstrated 85% stenosis of the innominate artery with calcification at the origin. We noted occlusion of the left subclavian artery at the origin (Figs. 1C and 1D). We also noted occlusion of both common iliac arteries. Bypass grafting had been made from the abdominal aorta to each of the bilateral common femoral arteries. Neither graft was stenosed or damaged (Fig. 2A). No obvious stenosis was noted in the right femoral artery, which we would later puncture for endovascular treatment (Fig. 2B).

**Treatment plan**

Because stenosis of the innominate artery and the left ICA were both progressive, we considered these sites to be eligible for treatment. Relatively large-diameter devices would be required to treat both lesions simultaneously. For this reason, we planned to place a sheath by surgical exposure and cut-down of the autogenous femoral artery distal to the graft with a small skin incision. If the first choice of puncture site were to fail, we planned to attempt direct puncture of the femoral artery graft.

**Treatment:** Under local anesthesia with minimal sedation, a small skin incision was made, and the right femoral artery was exposed by a cardiovascular surgeon. An attempt was made to insert the sheath via the autogenous femoral artery distal from the graft. However, it was difficult to pass a wire into the graft. Therefore, after complete exposure of the femoral artery graft, a purse string suture was applied using a 6-0 Prolene, followed by insertion of a 9 French (Fr) sheath by direct puncture of the graft (Figs. 2C and 3).

PCI was performed by a cardiologist. A drug-eluting stent (Xience Xpedition 3.5 mm × 23 mm; Abbott Vascular, IL, USA) was placed in the anterior descending artery (F7) successfully. Next, a neurosurgeon performed left carotid artery stenting (CAS). A 9 Fr Brite tip (Cordis, Johnson & Johnson, Fremont, CA, USA) was guided to the left common carotid artery (CCA), and the stenotic lesion was crossed with a FilterWire EZ (Boston Scientific) which was subsequently deployed at the distal ICA. After pre-dilation with a balloon (Jackal RX 3.0 mm × 40 mm. Kaneka Medical Products, Osaka, Japan), a self-expandable stent (Precise 9.0 mm × 40 mm. Cordis, Johnson & Johnson) was deployed at the stenotic site, followed by post-dilation up to 4.0 mm with a balloon (Jackal RX 4.0 mm × 30 mm). CAS was completed without complication. No bradycardia or hypotension occurred during the procedure. Plaque protrusion was not detected by intravascular ultrasound following stent placement (Fig. 4).

For subsequent innominate artery stenting, the right brachial artery was exposed and cut-down via a small incision. A 6 Fr shuttle guiding sheath (Cook Medical, Bloomington, IN, USA) was placed. Because it was difficult to pass the stenosis in innominate artery from the femoral side, a Radifocus 0.035-inch guidewire (Terumo, Tokyo, Japan) and a 4 Fr catheter were advanced from the brachial side and passed the stenosis, which was then snared from the right femoral artery to establish through-and-through brachial-femoral wire access. To protect both the VA and the ICA from brachial side, the guidewire had to be re-positioned distal to the brachial artery. The 4 Fr catheter inserted from the femoral side was guided to...
the brachium by tracking the guidewire. After withdrawing the guidewire from the brachial side, a Radifocus 0.035-inch stiff 300-cm guidewire was inserted from the femoral side, and its tip was placed more peripherally to the brachial guiding sheath. From the brachial side, a Carotid GuardWire PS (Medtronic, Minneapolis, MN, USA) was advanced coaxially with the 4 Fr catheter and was placed in both the right ICA and right VA for dual-distal protection (Figs. 5A and 5B).

Thereafter, the system was advanced through a 9 Fr Brite tip (Cook Medical) delivered from the femoral side. After pre-dilation of the stenosis using an over-the-wire balloon-catheter (Mustang 6.0 mm × 40 mm. Boston Scientific), a balloon-expandable stent (Assurant 10 mm × 30 mm. Medtronic) was placed (Figs. 5C and 5D). The Carotid GuardWire PS in the right VA was retrieved after sufficient irrigation with heparinized saline through the 4 Fr catheter which had been placed just below the balloon. The Carotid GuardWire PS in the right ICA was retrieved after confirming the absence of thrombus or plaque by aspirating 30 mL of blood using an aspiration catheter. Intravenous unfractionated heparin (3000 units) was administered at the time of catheter insertion in the right femoral artery. An additional 4000 units were administered prior to coronary artery balloon dilation. Because the activated clotting time (ACT) prior to CAS was 173 seconds, an additional 5000 units of heparin were administered and maintained at 1000 units/h. At the end of treatment, heparin was not reversed. Subsequent hemostasis of the femoral artery graft was obtained via purse string suture ligation at the puncture site. Similarly, the cut-down site at the brachial artery was closed with a purse string suture. The procedure time was 7 hours and 24 minutes. The volume of contrast agent used was 430 mL. Oral dual-antiplatelet therapy and intravenous argatroban at 60 mg/day were continued in the post-procedural period.

Some hours after the procedure, left lower extremity weakness (manual muscle testing 3+/5) was detected. Subsequent brain MRI revealed multiple small areas of hyper-intensity on diffusion-weighted image, primarily within the right frontal lobe. Thus, intravenous edaravone infusion was added to the antithrombotic regimen, after which neither ischemic lesion enlargement nor neurological exacerbation was observed. Both puncture sites healed well without subcutaneous hematoma formation or infection. Rehabilitation was initiated early after the procedure with rapid resolution of the left lower extremity weakness. The patient was transferred to another hospital for rehabilitation on the 22nd post-procedural day with a modified Rankin scale of 1, being able to perform activities of daily living independently. He was able to walk without assistance.

Discussion

This case demonstrates that even in cases with aorto-femoral bypass grafting, endovascular treatment can be performed safely by direct puncture of a femoral artery graft with surgical exposure and hemostasis with purse string suture ligation. We suggest that the risk of puncture site complications may be low.

To our knowledge, there are few reports of complications following graft puncture for diagnostic angiography or endovascular therapy. AbuRahma et al. reported puncture...
Direct Graft Puncture for Simultaneous Endovascular Treatment

including five with subcutaneous hematoma requiring blood transfusion, three with lower extremity ischemia, and one with retroperitoneal hematoma. The mean sheath size was 6.3 Fr (4–10.5 Fr), and 93.5% of the patients received manual compression for hemostasis. In other patients, hemostasis was achieved using devices, with the exception of one case in which the device was surgically removed. In these reports of percutaneous puncture of femoral artery graft (Table 1), puncture site complications were considered to be relatively minor. Nevertheless, this incidence is significant when compared with puncture site complication rate of 0.81%–2.6% in the setting of conventional femoral artery puncture.9,10 Because greater than 90% of these graft punctured cases had employed manual compression for hemostasis, our case suggests that direct graft puncture with surgical exposure and hemostasis with purse string suture may be safer. However, there is one report of pseudoaneurysm for-
mation in a bypass graft several years following puncture, suggesting that long-term follow-up may be necessary.11)

In our case, a Dacron graft was punctured. In most previous reports, the punctured graft was composed of either polytetrafluoroethylene (ePTFE) or Dacron (polyethylene terephthalate). Although composition of graft material appears to be unrelated to incidence of puncture site complications,4,5) this relationship remains unclear.

In previous reports, the femoral artery grafts were punctured fewer than 10 years following placement. In our case, the femoral artery graft had been placed 25 years prior to presentation. Nevertheless, graft puncture and hemostasis were performed safely. To our knowledge, since the 1981 publication of a detailed report concerning deterioration of Dacron grafts,12) there have been no further studies. According to the 1981 study, thinning or rupture due to degeneration was observed in 3% of the Dacron grafts within three or more years after placement. Graft durability is believed to have improved since 1990s. However, one study reports non-anastomotic pseudoaneurysms in grafts manufactured during this period, particularly among grafts placed in the groin.13)

Long-term follow-up of graft puncture sites may be necessary.

In our case, despite our use of a large-diameter (9 Fr) sheath, we show that puncture site complications may be prevented by closing the puncture site with sutures. Because there is a trend toward the use of large sheath sizes, longer ACT on sheath removal, and older age in patients with puncture site complications,7) we believe sheath size should be minimized as much as possible. Because the Assurant device, which we used for innominate artery stenting, could be used with a 6 Fr sheath, we had the option to employ a 6 Fr ultra-long sheath. Nevertheless, we employed a long sheath instead of ultra-long sheath, as we required control at the graft puncture site during the procedure. According to the device specifications, an 8 Fr guiding catheter was also available. Nevertheless, we used a 9 Fr long sheath and a 9 Fr guiding system in light of the possibility of loss of operability caused by friction in the catheter. A previous report4) showed no significant differences in the incidence of puncture site complications compared with puncture of the autogenous femoral artery, when a 5 Fr or 6 Fr sheath was placed percutaneously in the graft, followed by manual compression hemostasis. This suggests that complications may not be increased even by percutaneous puncture of the graft and manual compression hemostasis, if the sheath size is 6 Fr or smaller.

Simultaneous endovascular treatment for multiple stenotic lesions as described in this case might increase the risk of embolic complications because of increased complexity of its procedure. According to a report of 69 cases of CAS coupled with endovascular treatment for other stenotic vessels simultaneously, perioperative ischemic complications were observed in only three cases (4.4%). The simultaneous procedures were considered more advantageous than two-stage treatment of different stenotic lesions because of decreases in both radiation exposure and use of the contrast agent.14) One report suggested no significant difference in the incidence of stroke or major cardiac events between simultaneous CAS and PCI groups, and separate CAS and PCI groups.15) As these reports suggest, simultaneous endovascular treatment for multiple stenoses, including the carotid artery, might not significantly increase ischemic complications. Thus, multidisciplinary simultaneous treatment may be preferable for patients with complicated access route selection.

In innominate artery stenting, ischemic complications have been reported in 2%–2.6% of patients treated without cerebral protection.16,17) Various protection methods have been reported. These include dual protection from the brachial side (as was employed in this case); dual protection from the femoral side; no protection of VA based on the prediction that antegrade blood flow in the VA will not reestablish for some time following resolution of innominate artery stenosis when subclavian steal was apparent preoperatively; and a distal retrograde approach by entering the CCA with surgical exposure and direct clamping of the CCA.18,19) There have been no comprehensive studies. These methods have been selected on a case-by-case basis according to the condition of the patient. In our case, we

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>N</th>
<th>Graft age (mean)</th>
<th>Graft material</th>
<th>Sheath size (mean)</th>
<th>Complications</th>
<th>Puncture/Hemostasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>AbuRahma</td>
<td>1992</td>
<td>95</td>
<td>1M–14Y (51M)</td>
<td>Teflon</td>
<td>4–7 Fr</td>
<td>11.6%</td>
<td>NA</td>
</tr>
<tr>
<td>Cowling</td>
<td>1996</td>
<td>65</td>
<td>NA</td>
<td>Dacron</td>
<td>4–11 Fr</td>
<td>12.3%</td>
<td>1: surgical cut-down</td>
</tr>
<tr>
<td>Gallagher</td>
<td>2005</td>
<td>123</td>
<td>4D–10.3Y (30M)</td>
<td>NA</td>
<td>4–10.5 (6.3) Fr</td>
<td>5.7%</td>
<td>8: hemostasis without manual compression*</td>
</tr>
</tbody>
</table>

*A clamp was used in five patients (4.1%), and Perclose (Possis Medical, Minneapolis, MN, USA) in three patients (2.4%). One required planned surgical removal of a placed intra-aortic balloon pump. Fr: French; M: month/months; NA: not available; Y: years.
presume that the embolic complication might have been caused by multiple passages of devices through the stenosis. Thus, we suggest that when the procedure is complicated, the team should employ a sufficient prevention strategy to reduce thromboembolic complications.

## Conclusion

This case suggests the feasibility and safety of direct graft puncture with surgical exposure and purse string suture for puncture site hemostasis. This method may be worth considering in patients in whom selection of access route for endovascular treatment is difficult.

## Disclosure Statement

The first author and all of the co-authors have no conflicts of interest regarding this paper.

## References