Successful Endovascular Treatment of Aortoiliac Bifurcation Stenosis Using an Empirically Based T and Protrude-Stenting with Self- and Balloon-Expandable Stents

KEN-ICHIRO SASAKI, HIDETOSHI CHIBANA, TAKAFUMI UENO, NAOKI ITAYA, MASAHIRO SASAKI AND YOSHIHIRO FUKUMOTO

Department of Cardio-Vascular Medicine, Kurume University School of Medicine, Kurume 830-0011, Japan

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Summary: A 73-year-old woman with arteriosclerosis obliterans (ASO) was underwent a crossover stenting for an aortoiliac bifurcation from the right common iliac artery (CIA) with a self-expandable bare-metal stent (SE-BMS); however, a new stenosis later occurred just behind the bifurcation of the left CIA. An ex vivo experiment demonstrated that culotte-stenting by additional implantation of a balloon-expandable bare-metal stent (BE-BMS) through stent struts of the SE-BMS would be empirically infeasible. Although we had initially planned a T-stenting for the additional implantation of a BE-BMS in the left CIA, we finally deployed the stent in the CIA with the proximal end protruding into the previously-implanted SE-BMS through the stent struts to avoid incomplete coverage of the stenosis by reference to the ex vivo experiments. The patient has had no recurrence for 36 months.

Key words arteriosclerosis obliterans, culotte-stenting, T-stenting, ex vivo test

INTRODUCTION

Endovascular treatment (EVT) by stent implantation has become a conventional therapy for type-A stenosis in the TASC classification of aortoiliac lesions [1]. Although simultaneous-kissing stent reconstruction of aortoiliac bifurcation with a self-expandable bare-metal stent (SE-BMS) and a balloon-expandable bare-metal stent (BE-BMS) has been reported as an effective strategy to treat atherosclerotic stenoses of the bifurcation [2], there are few reports of additional T-stenting of a BE-BMS onto the struts of the SE-BMS for reconstruction of a bifurcation with atherosclerotic stenoses. Moreover, there is no report of a culotte-stenting of BE-BMS through the struts of the previously-implanted SE-BMS to treat the bifurcation stenosis. Here we demonstrate the infeasibility of the culotte stenting ex vivo and then report a successful T and Protrude-, but not T-, stenting to treat the stenosis by reference to the ex vivo experiments.

CASE REPORT

A 73-year-old woman, who had undergone medical treatment for hypertension and diabetic mellitus for 11 years, complained of intermittent claudication of the right lower-limb. The ankle-brachial pressure index (ABI) of the right and left lower-limbs were 0.6 and 0.97, respectively. The angiogram showed severe atherosclerotic stenosis of the right common iliac artery (CIA) (Fig. 1-A) and total occlusion of the right internal iliac artery. We diagnosed arteriosclerosis obliterans (ASO) and performed an EVT for the stenosis, which was classified as TASC A-type lesion [1]. After...
dilation of the stenosis with an 8.0×40 mm balloon catheter (Jackal RX, Kaneka Medical, Osaka, Japan), a part of the atherosclerotic plaque shifted to the abdominal aorta through the bifurcation of the right CIA, but not into the left CIA. Accordingly, we performed a crossover stenting across the bifurcation of the left CIA with a 10×40 mm SE-BMS (Zilver 518, Cook Medical, Bloomington, USA) to fully cover the shifted plaque (Fig. 1-B). The stenting did not impair the blood inflow to the left lower limb and again there was no atherosclerotic plaque shift into the left CIA. The ABI of the right and left lower-limbs recovered to 1.10

**Fig. 1.** Angiographic photos of abdominal and common iliac arteries in the first EVT

(A) The orange arrow indicates a severe atherosclerotic stenosis in the bifurcation of the right CIA, (B) The orange dotted arrow means the range of a SE-BMS implanted for the stenosis, (C) The light blue arrow indicates a severe stenosis in the bifurcation of the left CIA 7 months after the previous stenting.

**Fig. 2.** Photos of an *ex vivo* experiment to test the possibility of the culotte-stenting with SE- and BE-BMSs (A) An expanded SE-BMS was fixed at the bilateral edge by manufactured silks and the SE-BMS was in part made the figure curved along the sidewall of a plastic tube. This situation was empirically mimicked the aortoiliac bifurcation where was implanted SE-BMS. A non-deployed BE-BMS was put through the strut of an expanded SE-BMS for trying an empirically culotte stenting. (B) A balloon on the BE-BMS began to deploy from the near side; however, the center and the far side of the balloon were not inflated. (C) The incompletely inflated balloon began to push the non-expanded BE-BMS forward and to do out of the way through the expanded SE-BMS (two orange head arrows). (D) The non-expanded BE-BMS was further pushed out of the away from the expanded-SE-BMS (three orange head arrows). (E) The balloon mounted on the BE-BMS was finally inflated all but the inflated-balloon was off the stent and moved to the near side, resulting that the non-expanded BE-BMS remained in the expanded SE-BMS.
and 1.02, respectively. The intermittent claudication of the right lower-limb disappeared. However, at 7 months after the stenting, intermittent claudication within a walking distance of 200 meters newly appeared in the left lower-limb, but not in the right. The ABI of the right and left lower-limbs were 0.98 and 0.86, respectively. The angiogram showed no stenosis in the previously implanted SE-BMS of the right lower-limb but revealed severe stenosis in the bifurcation of the left CIA (Fig. 1-C). The stenosis existed just behind the bifurcation next to the stent wall.

To evaluate suitable strategies to treat the stenosis, we empirically tested how deformations would occur in the stent structure after a dilation of the stent struts with an 8.0×20 mm balloon catheter (Jackal RX, Kaneka Medical, Osaka, Japan). The cross-sectional balloon size of 8.0 mm corresponded to the cross-sectional size of the left CIA. The stent struts were initially dilated within the cross-sectional balloon size and resulted in the deformation of the stent structure. However, the deformation immediately restored to its former state after deflation of the balloon due to the shape-memory effect of the stent. Next, we empirically checked whether a culotte-stenting by an additional implantation of an 8.0×27 mm BE-BMS (Express LD, Boston Scientific, Natick, USA) through the stent struts of the previously implanted SE-BMS (Fig. 2-A) would be feasible. The balloon of the BE-BMS gradually began to inflate in the struts of a deployed SE-BMS, which was the same as the previously implanted SE-BMS, from the proximal side of the catheter. However, the stent did not expand at all (Fig. 2-B). The non-expanded stent balloon was pushed out of the struts of the SE-BMS (Fig. 2-E). These results suggested that a T-stenting would be more suitable than a culotte-stenting to treat the stenosis by the additional implantation of a BE-BMS into the previously implanted SE-BMS.

After the above preliminaries, we performed the planned EVT via the left femoral artery. A 0.018-inch guidewire (Treasure, Asahi Intec, Aichi, Japan) was advanced into the aortic aorta through the stenosis of the left CIA and the struts of the previously implanted SE-BMS. We dilated the stenosis with a balloon (Jackal RX, Kaneka Medical, Osaka, Japan) and implanted the BE-BMS next to the wall of the previously implanted SE-BMS with a T-stenting technique. At the stent implantation, we deployed the BE-BMS in the left CIA with the proximal end protruding into the previously-implanted SE-BMS through the stent struts within a few millimeters above the aortoiliac bifurcation to avoid incomplete coverage of the stenosis (Fig. 3-A, 3-B, and 3-C). Intravascular ultrasound (IVUS) (Visions PV.018, Volcano, San Diego, USA) showed that a part of proximal edge of the implanted BE-BMS was located in the struts of the previously implanted SE-BMS and that the BE-BMS fully covered the stenosis without any stent deformation. The ABI of the right lower-limb recovered to 1.05 and the intermittent claudication of the limb disappeared, indicating successful EVT for the limb. At 9 months after the EVT, the angiographic success was maintained on angiography and there was no significant pressure gradient (<10 mmHg) between the aorta and the left CIA. The ABI of both left and right lower-limbs have been maintained at more than 1.0 with no recurrence of intermittent claudication as of 36 months after the final treatment.

*Fig. 3. Angiographic photos of abdominal and common iliac arteries in the second EVT (A) A non-deployed BE-BMS was delivered next to the wall of the previously-implanted SE-BMS from distal of the left CIA, (B) The BE-BMS was deployed in the left CIA with the proximal end protruding in the previously-implanted SE-BMS through the stent struts, (C) The orange dot arrow and lines indicate the range of a previously-implanted SE-BMS. The light blue dot arrow and lines do the range of an additionally-implanted BE-BMS.*
DISCUSSION

In this case, the patient had intermittent claudication of the right lower-limb due to atherosclerotic obliterans and the symptoms markedly restricted her daily life. Although supervised exercise training is recommended as an initial treatment modality for peripheral arterial disease patients with intermittent claudication in the ACC/AHA Guidelines [1], consistent lower back pain prevented the patient from doing exercise training. Therefore, we performed EVT for the right CIA type-A stenosis in this patient. Although SE-BMS implantation to the CIA was successful with no problem in the angiographic finding for the aortoiliac bifurcation lesion, the TAP-stenting technique may be feasible, we empirically tested the strategy before training. Therefore, we performed EVT for the right CIA type-A stenosis in this patient. Although SE-BMS implantation to the CIA was successful with no problem in the angiographic finding for the aortoiliac bifurcation lesion, the TAP-stenting technique may be feasible, we empirically tested the strategy before training. Therefore, we performed EVT for the right CIA type-A stenosis in this patient. Although SE-BMS implantation to the CIA was successful with no problem in the angiographic finding for the aortoiliac bifurcation lesion, the TAP-stenting technique may be feasible, we empirically tested the strategy before training. Therefore, we performed EVT for the right CIA type-A stenosis in this patient. Although SE-BMS implantation to the CIA was successful with no problem in the angiographic finding for the aortoiliac bifurcation lesion, the TAP-stenting technique may be feasible, we empirically tested the strategy before training. Therefore, we performed EVT for the right CIA type-A stenosis in this patient. Although SE-BMS implantation to the CIA was successful with no problem in the angiographic finding for the aortoiliac bifurcation lesion, the TAP-stenting technique may be feasible, we empirically tested the strategy before training. Therefore, we performed EVT for the right CIA type-A stenosis in this patient. Although SE-BMS implantation to the CIA was successful with no problem in the angiographic finding for the aortoiliac bifurcation lesion, the TAP-stenting technique may be feasible, we empirically tested the strategy before training. Therefore, we performed EVT for the right CIA type-A stenosis in this patient.
Compliance with ethical standards

The authors complied with human study guidelines of Kurume University Hospital and the patient provided informed consent for publication of this case report.

Declaration of conflicting interest

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