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One-piece bifurcated stent-graft with bridging technique for chronic iliocaval occlusion: a case report of successful filter retrieval and venous reconstruction after 4,913 days of indwelling

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Purpose: To propose a novel stent implantation technique for chronic iliocaval occlusion—the One-piece Bifurcated Stent-Graft with Bridging Technique (OBSGBT)—which utilizes a one-piece bifurcated arterial stent-graft as the main body, bridged with venous stents.
Case report: We report a 76-year-old male patient who underwent retrievable inferior vena cava (IVC) filter placement for lower extremity deep venous thrombosis 4,913 days prior. Over time, he developed chronic complete occlusion of the left iliac vein and severe stenosis of the IVC below the filter. After successful filter retrieval, the iliocaval venous channel was reconstructed using the OBSGBT. At 1-year follow-up, all stent segments remained patent, with no stent migration, fracture, or thrombosis.
Conclusion: For filter-related chronic iliocaval occlusion, the OBSGBT appears feasible, safe, and effective. Its preliminary outcomes appear promising compared with conventional kissing-stent techniques, warranting further investigation in larger cohorts.

KEYWORDS
chronic iliocaval occlusion, iliocaval occlusion, one-piece bifurcated stent-graft with bridging technique, ultra-long indwelling retrievable inferior vena cava filter, venous stent

Introduction

Retrievable IVC filters play an important role in preventing pulmonary embolism in elderly patients with lower extremity deep venous thrombosis. However, long-term filter retention may lead to chronic iliocaval occlusion, with an incidence of 2%–25% (1, 2). The standard treatment strategy includes filter retrieval, balloon angioplasty, and stent implantation. The real challenge lies in maintaining long-term patency after recanalization. Conventional techniques—such as the apposition, double-barrel, inverted-Y fenestration, and skip-stent techniques—have shown limited efficacy in the setting of complex anatomical changes induced by ultra-long filter dwell time (2).

This paper aims to evaluate the feasibility and preliminary efficacy of the OBSGBT for chronic iliocaval occlusion, offering a new therapeutic approach for filter-related complex venous lesions.

Case report

A 76-year-old male presented with bilateral lower extremity swelling and pain for more than 10 days. He had undergone retrievable IVC filter implantation and lower extremity venous thrombolysis at another hospital 4,913 days earlier for deep venous thrombosis, followed by oral warfarin. Physical examination revealed marked edema and pigmentation of the left lower limb, a positive calf compression test, and tenderness at the fossa ovalis. His medical history included a stroke 2 years prior, and he had been living at high altitude. Laboratory findings: INR 1.04, red blood cell count 6.35×10^{12}/L, hemoglobin 192 g/L, hematocrit 58.2%, and negative anticardiolipin antibodies and lupus anticoagulant. Contrast-enhanced abdominal CT showed an IVC filter in place, with curvilinear low-attenuation and gas-density shadows within the filter lumen, and low-attenuation shadows in the IVC and left iliac vein, suggestive of thrombosis.

Over time, the patient developed ultra-long-term filter-related chronic iliocaval occlusion with severe stenosis of the IVC below the filter, manifested by recurrent bilateral leg swelling, pigmentation, and active ulcers. The recommended treatment was filter retrieval, balloon angioplasty, and stenting. Given the filter dwell time of 4,913 days, dense fibrous adhesions had formed between the filter and the IVC wall, with the struts completely encapsulated by neointimal hyperplasia, making retrieval extremely risky. Nevertheless, as shown by Raju and Neglén, percutaneous recanalization remains feasible in this population (3, 4). Therefore, after thrombolytic therapy to alleviate symptoms, we attempted filter retrieval and iliocaval reconstruction.

Imaging and interventional procedure

Venography via the left dorsal foot demonstrated extensive filling defects in the anterior tibial, posterior tibial, and popliteal veins, with slow contrast clearance; the superficial femoral and iliac veins were not visualized. Right foot venography showed minor filling defects in the corresponding veins.

The right femoral vein and left anterior tibial vein were punctured, and 5-Fr thrombolytic catheters were inserted, with markers positioned in the IVC and the superficial femoral vein. After 5 days of catheter-directed thrombolysis, repeat venography revealed an approximately 85% stenosis of the right superficial femoral-iliac vein, a small filling defect below the filter with rapid contrast washout, and extensive filling defects in the left iliac vein with minimal collateral circulation.

An 8-Fr sheath was placed on the left side, and the right femoral vein was upsized to a 22-Fr sheath. A 12-Fr steerable sheath was introduced, through which a snare was advanced to the IVC. A 260-cm stiff guidewire (Amplatz Super Stiff, 0.035 inch; Boston Scientific Corporation, Marlborough, MA, USA) was captured by the snare and externalized. A 12-mm × 80-mm balloon catheter (AT120144, Atlas PTA; Bard Peripheral Vascular, Inc., Tempe, AZ, USA) connected to an inflation device (KDL-IN30; Shanghai Kindly Medical Instruments Co., Ltd., Shanghai, China) was used to dilate the IVC and the filter, and the filter was retrieved using the loop technique. Post-retrieval venography showed smooth flow through the iliocaval segment with minimal contrast extravasation (Figure 1). The long sheath was then removed, leaving the stiff guidewire in place. A 14-14-120 mm one-piece bifurcated covered arterial stent-graft [Aegis; Shanghai MicroPort Endovascular MedTech (Group) Co., Ltd., Shanghai, China] was deployed via the guidewire, followed by implantation of a 14-mm × 80-mm self-expanding vascular stent (Viel 14080; Angiomed GmbH & Co. Medizintechnik KG, Karlsruhe, Germany) and a 14-mm × 120-mm iliac venous stent (ZY1414120X, Zynlastic; Zylox-Tonbridge Medical Technology Co., Ltd., Hangzhou, China) in the left and right iliac veins, respectively, with a 2–3 mm overlap with the bifurcation limbs (Figure 2). The patient recovered uneventfully. Postoperatively, rivaroxaban was administered. At 1-year follow-up, the patient's lower-limb swelling and pain had resolved, and the previously active ulcer had completely healed. He remained on rivaroxaban 20 mg once daily with good adherence. Follow-up imaging consisted of duplex ultrasound at 3, 6, and 12 months and venography at 12 months, which demonstrated patency of all stent segments, with no intimal hyperplasia or thrombosis in the bifurcation-bridge overlap zone.

Discussion

Although retrieval of an ultra-long-dwell IVC filter is extremely challenging, we successfully removed the filter using simultaneous balloon dilation of the vessel and filter combined with the loop technique (5). However, the real challenge remains maintaining sustained patency after iliocaval recanalization. Based on existing technologies and the specific needs of this case, we developed a novel iliocaval reconstruction technique—the One-piece Bifurcated Stent-Graft with Bridging Technique (OBSGBT)—which incorporates a "one-piece bifurcated main body + modular venous stent bridging" concept (6).

The technique employs a large-diameter one-piece bifurcated arterial stent-graft, with the main body placed in the distal IVC and its two branches extending to the origin of the common iliac veins. Each branch is bridged by a self-expanding venous stent deployed in the iliac vein, with a 2–3 mm overlap (Figure 3A). After sequential balloon pre-dilation of the stenotic iliocaval segments, the bifurcated stent is introduced from one femoral vein and precisely deployed. The bridging stent is then advanced from the contralateral femoral vein, overlapping the bifurcation limb by 2–3 mm. Finally, the external iliac vein stents are deployed, completing the full flow channel reconstruction. The main stent is pre-shaped in a Y configuration, matching the iliocaval confluence anatomy—this is the fundamental difference from conventional assembled stent techniques and represents a direction toward anatomical physiological repair.

We chose an arterial stent-graft as the main body because arterial stents offer greater radial force, enabling reliable

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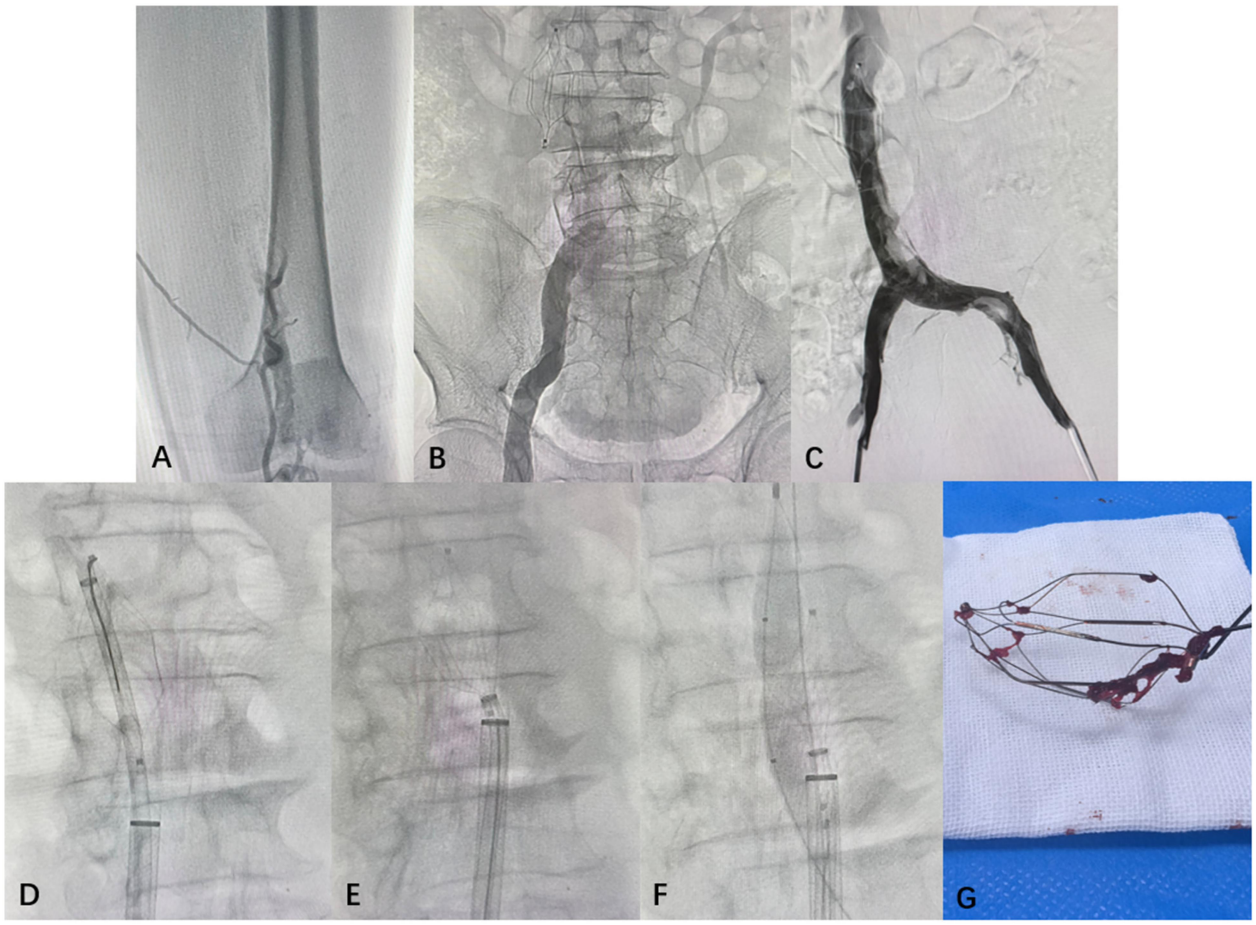


FIGURE 1
Lower extremity venography and retrieval of the ultra-long-dwell (4,913 days) IVC filter. **(A)** Left lower extremity venography; **(B)** Right lower extremity venography; **(C)** Simultaneous bilateral venography after catheter-directed thrombolysis; **(D)** Snare attempt to engage the filter apex; **(E)** Snare and stiff guidewire capturing the filter; **(F)** Simultaneous balloon dilation of the IVC and filter; **(G)** Retrieved filter with adherent thrombus and fibrotic endothelium.

anchoring and remodeling of the fibrotic venous conduit, counteracting elastic recoil of chronic occlusive lesions and compression from filter struts. Therefore, in patients with chronic iliocaval stenosis who have lost normal venous compliance and flexibility, arterial stents may confer better prognosis (6).

The OBSGBT, with its single-channel "bifurcation-bridging-continuation" design, eliminates the inter-stent gap—a major trigger for thrombosis. By optimizing the outflow angle, it reduces vortex and stagnant flow, which is particularly advantageous in the low-pressure, low-flow venous system. The bridging design allows limited relative movement between components in the pelvic curvature, thereby avoiding stress concentration and stent fracture. Kissing stents at the iliac bifurcation experience abnormal alternating stresses due to smaller diameters and sharper angulation, whereas the one-piece bifurcated arterial stent reduces abnormal stress transmission. The short transitional segments (2–3 mm overlap) between the bifurcated main body and the bridging stents serve as a buffer, distributing strain over a longer area, significantly reducing the risk of focal fracture or intimal tear. Regular ultrasound surveillance is recommended, with balloon dilation of the bridging segment if necessary.

Compared with five conventional techniques for chronic iliocaval occlusion—apposition, double-barrel, inverted-Y fenestration, 3-stent, and skip-stent techniques (Figure 3)—the core differences lie in the geometric configuration and flow channel design at the iliocaval confluence (1). The apposition technique involves placing a second stent closely adjacent to an already deployed iliocaval stent, deliberately leaving a short unsupported segment of vessel wall. This unsupported area creates local turbulence and thrombosis, leading to high re-intervention rates, and it has largely been abandoned. The double-barrel technique (also referred to as kissing stents) involves parallel implantation of two stents from both common iliac veins into the IVC, creating a dual-channel configuration—the most common approach for iliocaval confluence lesions. However, long-term compliance mismatch between the two stents may cause one to compress the other, resulting in outflow stenosis (7). The inverted-Y fenestration technique places a main IVC stent, then a second stent is deployed through the mesh interstices (fenestration) to maintain contralateral flow, forming an inverted-Y shape. It is mainly used for staged contralateral stenting, extensive IVC disease, or when insufficient space exists for the double-barrel approach. Its primary complications relate to the fenestration site, with

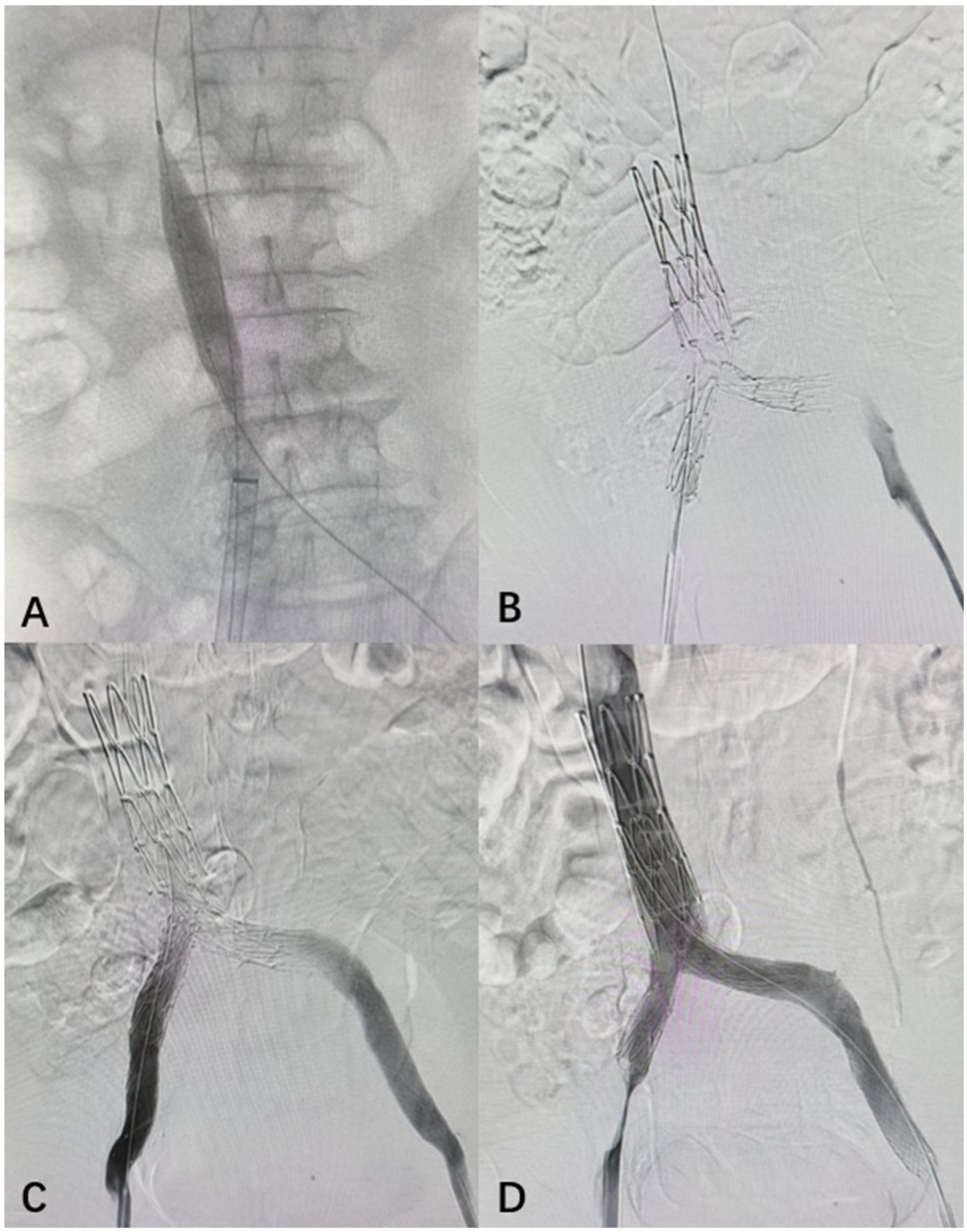


FIGURE 2
Implantation of the novel stent configuration. **(A)** Post-retrieval balloon dilation of the stenotic IVC; **(B)** Deployment of the one-piece bifurcated covered arterial stent-graft; **(C)** Implantation of the left iliac venous stent; **(D)** Implantation of the right iliac venous stent.

restenosis or occlusion being the main reasons for high re-intervention rates (1). The 3-stent technique is an option for complex iliocaval confluence lesions, especially when the IVC is extensively involved, providing additional support against post-thrombotic recoil; however, more stents create more inter-stent cavities and thrombotic opportunities. The skip-stent technique places a main stent in the IVC and separate stents in each common iliac vein, leaving approximately 1 cm of bare "skip zone" at the confluence without overlap or connection. This obviously is not suitable for diffuse stenosis, which is in fact the rule in iliocaval disease (8). Neglén et al. reported a 4-year primary patency of 77% and re-intervention rate of 8% for the double-barrel technique, versus 41% primary patency and 37% re-intervention for inverted-Y fenestration. The skip-stent technique achieved a 30-month patency of 74% with an early thrombosis rate of about 2% (1, 8).

In all techniques that require parallel or interlocking stents, the two stents typically cannot fully appose, leaving a triangular zone of stagnant flow—the inter-stent cavity (1). This cavity is an important contributor to post-stenting thrombosis, persistent iliocaval stenosis, and re-intervention. In the high-pressure, high-flow arterial system, the sheer stress from rapid flow can wash out small thrombi; however, in the low-pressure, slow-flow venous system, turbulent flow and abnormal shear stress within this cavity significantly increase the risk of thrombosis and intimal hyperplasia. Therefore, a smaller inter-stent cavity confers greater clinical advantage (9). We performed a preliminary theoretical estimation of the inter-stent cavity.

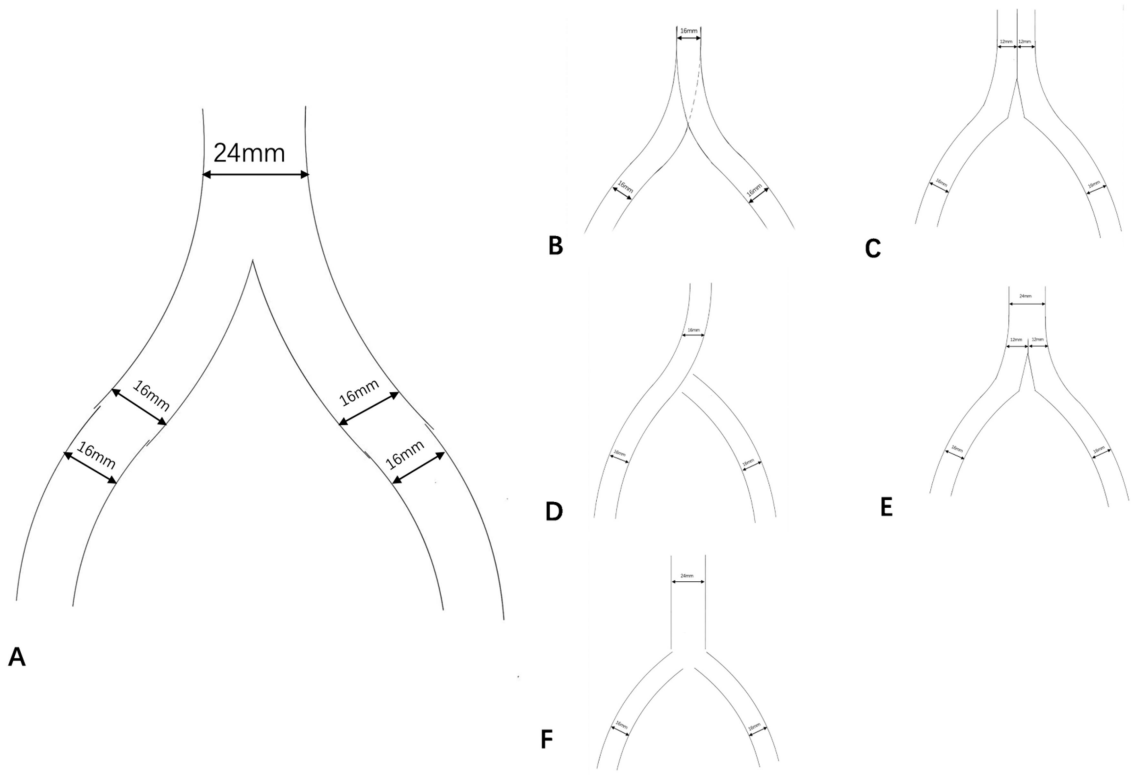


FIGURE 3
Comparison of the OBSGBT with conventional iliocaval stent configurations. **(A)** OBSGBT schematic; **(B)** Apposition technique; **(C)** Double-barrel technique; **(D)** Inverted-Y fenestration technique; **(E)** 3-stent technique; **(F)** Skip-stent technique. Panels B–F adapted from Barbati et al. (8).

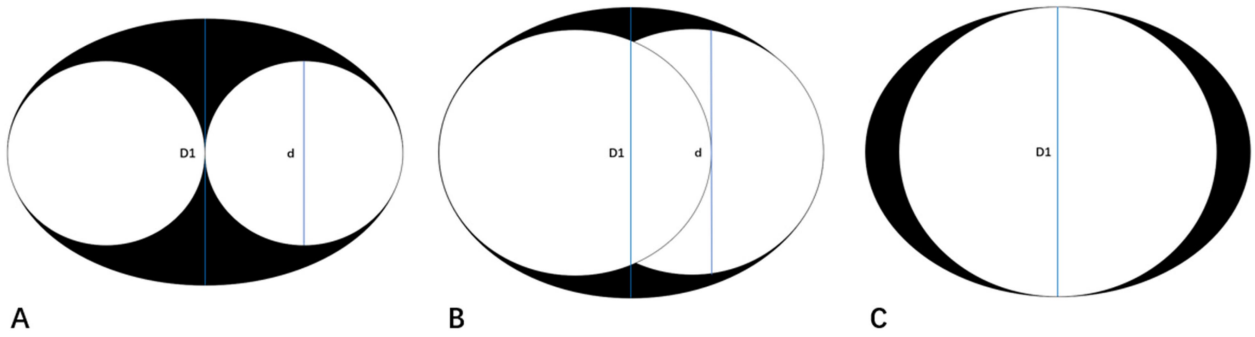


FIGURE 4
Comparison of the inter-stent cavity among various iliocaval stent techniques. The black areas represent the inter-stent cavity. **(A)** Double-barrel technique; **(B)** Inverted-Y fenestration/apposition technique; **(C)** OBSGBT/skip-stent technique.

Under typical conditions, the IVC is elliptical in cross-section; let D_1 be the short axis, D_2 the long axis, and d the stent diameter. The inter-stent cavity area for Figure 4A equals $\frac{\pi}{4}(D_1D_2 - 2d^2)$; for Figure 4B, $\frac{6\pi D_1D_2 - (8\pi+3\sqrt{3})d^2}{24}$; and for Figure 4C, $\frac{\pi}{4}(D_1D_2 - d^2)$. In practice, determining the ratio of stent diameter to the IVC short axis is complex. In the double-barrel technique, each stent diameter is approximately 80% of the IVC short axis; in the inverted-Y fenestration, the oblique plane of the two stents must fit within the long axis of the IVC; while for the OBSGBT, the bifurcation body should slightly oversize (10%–20%) the IVC diameter for better wall apposition. Both inverted-Y fenestration and OBSGBT tend toward the geometry in Figure 4B; however, the former involves two separate stents, whereas the OBSGBT uses a single one-piece bifurcated stent, making it closer to Figure 4C. Using the reference diameters marked in Figure 3, we estimated the inter-stent cavity to be A > B > C (Figure 4). Thus, single-stent implantation results in a smaller inter-stent cavity compared with parallel stents, and eliminates bare zones, making it more suitable for diffuse iliocaval disease.

The OBSGBT technique closely aligns with the treatment principles of major international guidelines, which recommend stent reconstruction for patients with symptomatic chronic iliocaval occlusion. Technically, the innovation of OBSGBT lies

in its use of a one-piece bifurcated arterial stent as the main body, which provides greater radial force to counteract fibrotic recoil, and its bridging design that eliminates the inter-stent cavity (10–12).

The OBSGBT also has potential limitations. The one-piece design usually entails higher metal coverage, which may increase the risk of post-procedural thrombosis. The bifurcation tips may impose focal stress on the vessel wall, with potential for long-term injury and restenosis. Moreover, patient-specific variations in venous diameter and bifurcation angle make a pre-shaped bifurcated stent less flexible in matching all anatomical variants compared with modular combinations. Currently, only a few exploratory studies have confirmed its technical feasibility, and large-scale, long-term follow-up data are lacking to assess its durability and safety.

In summary, the OBSGBT offers advantages in eliminating inter-stent gaps, reducing the inter-stent cavity, and remodeling the stenotic lumen through its integrated bifurcation and bridging design. It aligns with the goal of anatomical and physiological repair and appears suitable for diffuse chronic iliocaval occlusion.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the First Hospital of Lanzhou University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

SL: Writing – original draft, Conceptualization, Writing – review & editing. WF: Formal analysis, Writing – original draft. JW: Methodology, Writing – original draft, Software. YC: Data curation, Writing – original draft, Formal analysis. GC: Conceptualization, Writing – original draft. GL: Visualization, Writing – original draft. LL: Writing – original draft, Writing – review & editing, Conceptualization.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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