Bilateral stenting at the iliocaval confluence

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Objective: **This study describes three techniques of stent placement at the iliocaval confluence for chronic nonmalignant obstruction and its stent-related outcome.**

Methods: **From 1997 to 2008, 115 patients (230 limbs) underwent bilateral stenting for iliocaval obstruction. All limbs were CEAP classified using clinical examination and duplex ultrasound study. Three techniques were compared: placement of two stents side by side in a "double-barrel" (group DB, n = 39); inverted Y stenting through a fenestra (window) created through the side braiding of a stent placed previously across the iliocaval confluence (group iY, n = 38); apposition of a stent as close as possible to a stent previously placed across the iliocaval confluence, leaving a small area unsupported between the stents (group A, n = 38). Patency was assessed with venography and duplex ultrasound imaging. Cumulative patency curves were calculated.**

Result: **Median age was 54 years (range, 14-76 years); female/male ratio was 2.8:1. Obstructions were primary in 141 limbs and postthrombotic in 89, and 29 required recanalization of occlusions. The C_{4-6} rate and ratio of limbs with postthrombotic obstruction were significantly higher in group iY vs group DB (49% and 32% [*P* = .049]; 47% and 28% [*P* = .022], respectively). The median follow-up was 12 months (range, 1-108 months) in 107 patients (93%). The overall primary, assisted primary, and secondary patency rates at 4 years were 61%, 92%, and 98%, respectively. The distribution of occluded stent systems (n = 4) and frequency of reinterventions (n = 29) were reflected in the primary and secondary patency rates for groups A, DB, and iY at 4 years (77% and 100%, 73% and 100%, and 41% and 90%, respectively). The frequency of reinterventions was significantly lower in group DB vs groups A and iY (8%, 32%, and 37%, respectively; *P* < .01).**

Conclusion: **Chronic iliocaval confluence obstruction is best managed by double-barrel stenting when feasible. The apposition technique requires a high reintervention rate owing to restenosis of the unsupported segment. The secondary stent patency appears to be less in limbs with postthrombotic occlusion. Primary stent patency of nonocclusive obstruction was inferior in group iY regardless of etiology of obstruction. However, inverted Y fenestration is the only choice in delayed contralateral stenting or when the inferior vena cava is extensively involved. There is no optimal solution to the treatment of the iliocaval confluence presently, and the choice of technique is decided by the extent, site, and type of obstruction. (J Vasc Surg 2010;51:1457-66.)**

Percutaneous stenting of the femoroiliocaval venous outflow, guided by intravascular ultrasound (IVUS) imaging, is presently the method of choice in the treatment of chronic venous obstruction. It is also the initial treatment in patients with combined obstruction and reflux disease.[1] Although the stent placement appears to be rather simple technically, attention to details is vital to achieve an optimal result. The endovenous procedure is minimally invasive, with low morbidity, long-term stent patency, a low rate of in-stent stenosis, and limited need for reinterventions. It results in sustained relief of limb symptoms, a high rate of healing of venous leg ulcers, in substantial improvement of quality of life, and in decreased disability.[2-6]

Most commonly, the obstructive disease is unilateral. In most of these limbs, an extension of the stenting into the inferior vena cava (IVC) is required when treating a focal obstruction adjacent to the confluence of the common iliac vein to avoid caudad migration and early recurrence of the stenosis.[7] Although the contralateral venous outflow is crossed, it does not appear to significantly impair the flow from the contralateral limbs so that thrombosis results.[5] There is presently no dedicated stent available to avoid this "jailing" of the contralateral outflow.

Bilateral iliac stenting with extension into the IVC is necessary when the iliocaval confluence is primarily involved or an obstruction of the contralateral iliac vein develops after previous iliac vein stent placement. This study describes different techniques of stent placement at the iliocaval confluence for chronic nonmalignant obstruction and its stent-related outcome.

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MATERIALS AND METHODS

A review of a venous stent database of 1607 limbs with information collected prospectively from 1997 to 2008 revealed 115 patients (230 limbs) who underwent bilateral stenting for occlusive or nonocclusive obstruction involving the iliocaval confluence. Primary lesions, so-called nonthrombotic iliac vein lesions (NIVL), are caused by focal nonocclusive external compression at arterial vessel crossings or by the inguinal ligament, or both, sometimes combined with intraluminal lesions such as webs and septa.[1]

The obstructive lesion was considered postthrombotic when:

- the patient had a known occurrence of deep vein thrombosis diagnosed with duplex US (DUS) imaging or ascending venogram and had subsequently been treated by anticoagulation; or
- findings on venogram (occlusion, stenosis or collaterals) or DUS imaging, or both, indicated previous deep vein thrombosis below the inguinal ligament noted by direct visualization of thrombus or indirect indication by partial or total inability to compress the vein. The different lesions have distinctive features on IVUS imaging.[1]

No patient had acute deep vein thrombosis, and none was treated by thrombolysis before stenting. The median duration of symptoms was 12 months (range, 2-360 months). The iliocaval confluence was stented in the same procedure or the contralateral stenting was performed at a later date.

All limbs were classified using the CEAP classification according to the reporting standards of the International Society for Cardiovascular Surgery (ISCVS)/Society for Vascular Surgery (SVS)[8,9] based on DUS study with standardized compression.[10,11] The patients were routinely surveyed at 3, 6, and 12 months after stenting and then annually with transfemoral or ascending venography and DUS imaging to assess patency. Patency was defined as visible flow throughout the entire bilateral stent system.

Reintervention was performed because of residual/recurrent symptoms or because of stent malfunction, including stent occlusion, presence of >50% in-stent stenosis, collaterals, and inflow or outflow abnormalities found on routine surveillance in the stented IVC or one or both of the stented iliac limbs, or both. Intervention in most limbs was performed based on venography, which was obtained when DUS imaging suggested stent malfunction. The type and frequency of reinterventions were noted.

Although the main end point of this study was not clinical outcome, some perioperative symptomatic outcomes are given. The study end point of legs with stasis ulceration was complete epithelialization. The degree of pain was evaluated perioperatively using a visual analog scale (VAS) from 0 to 10, where 10 indicates the most severe pain.[12] Swelling was assessed as grade 0 (absent), grade 1 (pitting, not obvious), grade 2 (visible ankle edema), and grade 3 (massive, encompassing the entire leg) according to reporting standards.

Technique. The diagnosis of obstruction, indications for iliofemoral stenting, technical details of unilateral endovenous stenting, and perioperative anticoagulation treatment have been described previously.[7,13-17]

DUS-guided venous access of the common femoral, femoral, or popliteal vein bilaterally was performed under general anesthesia in all patients. Both nonocclusive and occlusive obstructions were always dilated before stent placement. Only braided stainless steel Wallstents (Boston Scientific, Natick, Mass) were used. Stents treating common iliac vein obstruction adjacent to the iliocaval confluence, whether they were unilateral or bilateral lesions, were frequently placed into the IVC (minimally 3 cm or further) to prevent caudad migration. Bilateral caudad extension was performed as necessary to cover the entire obstructive lesion and to ensure an adequate inflow. Principally, three different techniques were used in this study:

1. Double-barrel technique (group DB; n = 39). After bilateral femoral vein access, bilateral guidewires were placed into the IVC, and a bilateral balloon venoplasty was performed with a "kissing balloon" technique (the same as used at the aortic bifurcation). Two braided stainless steel stents (9 cm long and 14 to 16 mm wide) were then placed and released concurrently starting at the same level in the IVC in a double-barrel fashion crossing the confluence into both iliac veins (Fig 1). Balloon dilation was repeated after the placement of the stents. This technique leaves an uninterrupted outflow from both iliac veins.
2. Inverted Y fenestration (group iY; n = 38). This technique is more complicated and requires a fenestration. A stent was placed that covers the iliocaval confluence unilaterally. Through a contralateral venous access, a guidewire was pushed through the mesh of the side of the braided stent. The penetration of the stent and placement of the guidewire through the side of the initially inserted stent may sometimes be difficult. Placement of a supporting sheath up to the side of the stent may aid passage. It is occasionally easier to pass a guidewire through the stented iliac vein to the contralateral iliac vein, catch it with a loop from that side, and pull it out through the sheath, creating a "body-floss" situation. This will stabilize the guidewire and sometimes makes the passage of a balloon easier through the side of the stent.

   Penetration of the stent may be facilitated by the use of a transjugular intrahepatic portosystemic shunt (TIPS) needle (Cook, Bloomington, Ind), which was applied in 10 patients in this study (Fig 2).[18,19] A low-profile balloon with tapered tip was then placed over the guidewire crossing the stent braiding and inflated, creating a small opening (fenestra) in the side of the stent. If the balloon cannot be passed, the dilator in the TIPS set may be pushed through the braiding to separate the steel wires. After sequential balloon dilation with larger, high-pressure Atlas balloons (14-16 mm diameter; Bard Peripheral Vascular, Inc, Tempe, Ariz), the braiding of the stent was deformed and a larger opening was created (Fig 3, *A*). The stainless steel wires of the braided stent do not appear to fracture during this maneuver, and the adjacent part of the stent seems to be unaffected.

   A stent at least the diameter of the contralateral stent was then inserted over the wire through the fenestration across the outflow of the previously inserted stent in an inverted Y configuration. A generous overlap was necessary to prevent foreshortening and retraction of the

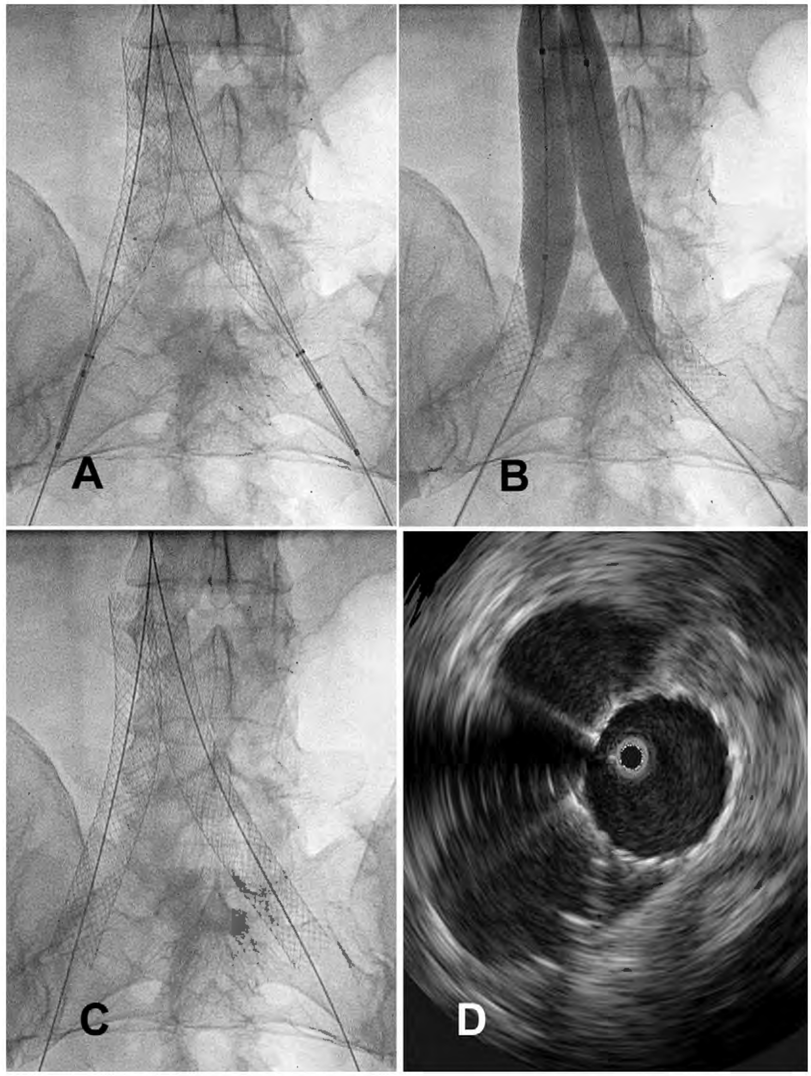

Fig 1. Images of stenting of the iliocaval confluence by the double-barrel technique. **A** After predilation by "kissing" balloons, same-sized stents are inserted and simultaneously released side-by-side in the inferior vena cava (IVC) and distally into each common iliac vein. **B,** The stents are dilated simultaneously after insertion, and **(C)** are shown well expanded with no kinking at the iliocaval junctions. **D,** This intravascular ultrasound (IVUS) image shows clearly the adjoining stents just above the confluence in the IVC. The *black circle* inside the stented vein represents the inserted IVUS catheter.

stent caudally through the fenestra on dilation (Fig 3, *C* and *D*). The initially stented iliac vein was crossed by the second stent. Fenestration was not routinely performed of the "jailing" stent unless the flow was considered impeded (Fig 4).

In the presence of bilateral iliac venous occlusion, guidewire recanalization, balloon dilation, and stenting were performed on one side. The contralateral side was then recanalized and access through the side of the previously placed stent was achieved using the techniques described above.

3. Apposition (group A; n = 38). This technique was the only one used before the year 2000, before the previously described techniques were applied. Presently, this technique is used only selectively in the event a penetration of the side of the stent fails during inverted Y fenestration. A stent overriding the iliocaval confluence on one side across the outflow of the contralateral iliac vein had been placed previously. Through a contralateral access, an additional stent was then placed as close as possible to the side of the previously placed stent (Fig 5). Owing to the design of the deployment device, this placement left a short (1- to 2-cm) cephalad vein segment between the stents uncovered. It should, therefore, be performed only when the cephalad, common iliac vein is relatively healthy.

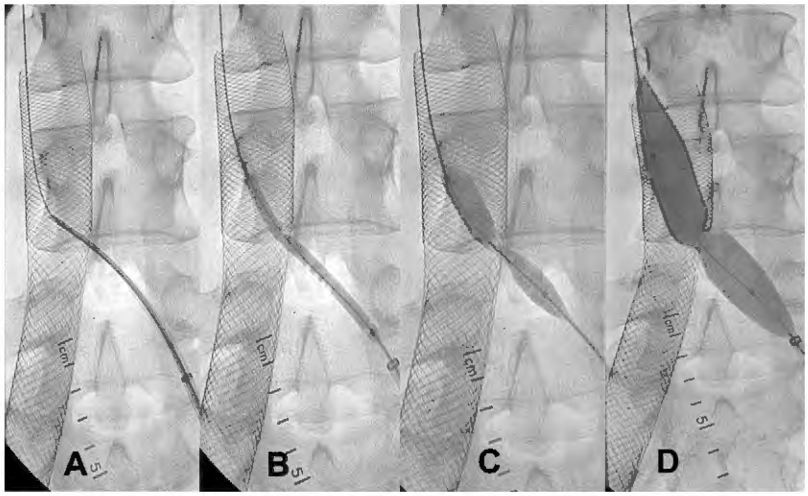

Fig 2. A transjugular intrahepatic portosystemic shunt needle, supported by a sheath, is pushed through the stent mesh. **A,** A stiff Glidewire is inserted through the needle. **B,** The needle is replaced by a low-profile small-diameter balloon that is inflated to separate the braided steel wires to allow insertion of a larger balloon. **C and D,** Sequentially larger high-pressure balloons are used to create a window (fenestra).

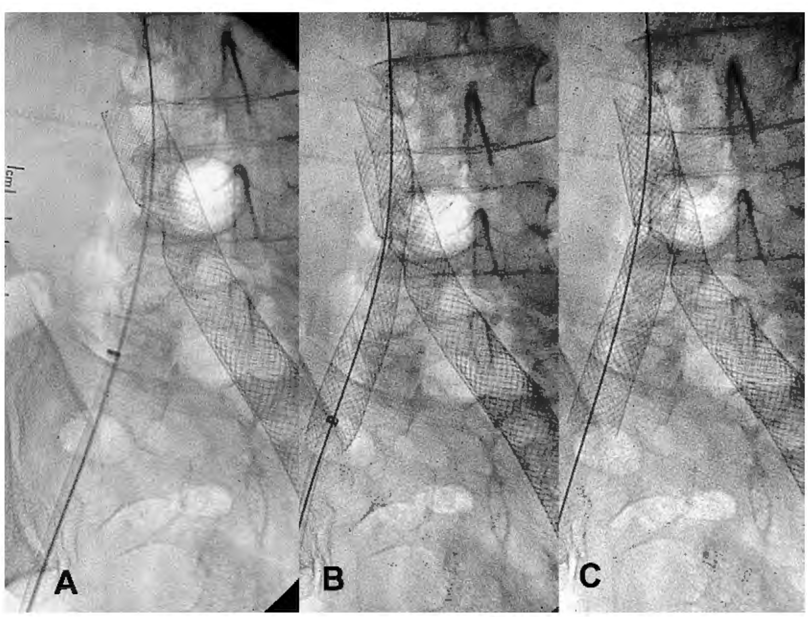

Fig 3. **A,** The deformation creating a fenestra in the side of the stent is clearly visualized. **B,** A stent of the same or larger diameter is deployed well into the inferior vena cava and distally to avoid slipping out of the fenestration on dilation. **C,** Final result after balloon dilation after stent insertion shows the outflow of the contralateral iliac stent limb is "jailed."

All patients received subcutaneous dalteparin (2500 U) preoperatively, and intravenous unfractionated heparin (3000 to 5000 U) was administered during the procedure. Postoperatively, a foot compression device was applied, subcutaneous dalteparin (2500 U) administered in the recovery room, and dalteparin (5000 U) was repeated in the morning before discharge. Patients who were stented for nonthrombotic disease were maintained on low-dose oral aspirin (81 mg daily) alone. Patients stented for postthrombotic obstruction who were already receiving warfarin preoperatively, those with prior recurrent deep vein thrombosis, or those known or preoperatively discovered to have thrombophilia, were anticoagulated with warfarin postoperatively, otherwise they were maintained on low-dose aspirin. Patients with a recanalization procedure and

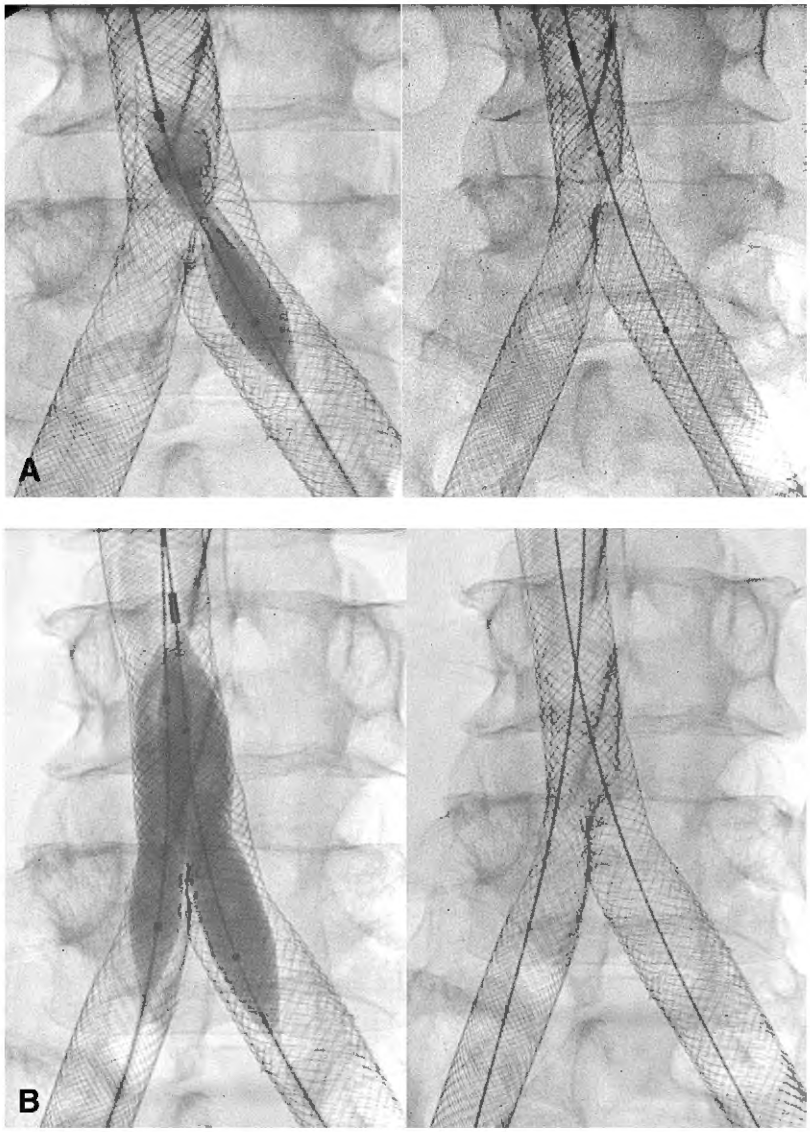

Fig 4. A, Fenestration of a stent, which is placed across the outflow of one stented limb after an inverted Y fenestration. **Left,** A balloon is placed through the side of the stent and dilated, **(right)** creating a fenestra allowing unimpeded outflow. **B,** The unilateral dilation may sometimes infringe on the previous created window and result in stenosis. **Left,** It may be useful to perform balloon dilation at the stent confluence by kissing balloon technique to **(right)** ensure an uninterrupted outflow from both iliac veins.

stenting were given therapeutic anticoagulation with dalteparin for 7 to 14 days and then converted to full-dose warfarin.

Statistical analysis. Categoric variables were analyzed by χ^2 test. Primary, assisted primary (patency after preemptive intervention), and secondary patency (patency after intervention for occlusion) rates, as defined by the reporting standards of the SVS/ISCVS,[8] were calculated using survival analysis with the Kaplan-Meier method. Patency was assessed as flow in both limbs of the stent system and in the stented IVC. The log-rank test was used to compare cumulative curves. Prism 3.0 software (GraphPad, San Diego, Calif) was used for analysis. Results are reported using P values, with $P < .05$ considered significant.

RESULTS

Stenting of the iliocaval confluence was performed in 115 patients (230 limbs). Median age was 54 years (range, 14-76 years), and female/male ratio was 2.8:1. The intervention was performed for NIVL, so-called compression lesions, in 141 limbs, and for chronic postthrombotic obstruction in 89 limbs. Nonocclusive obstruction was

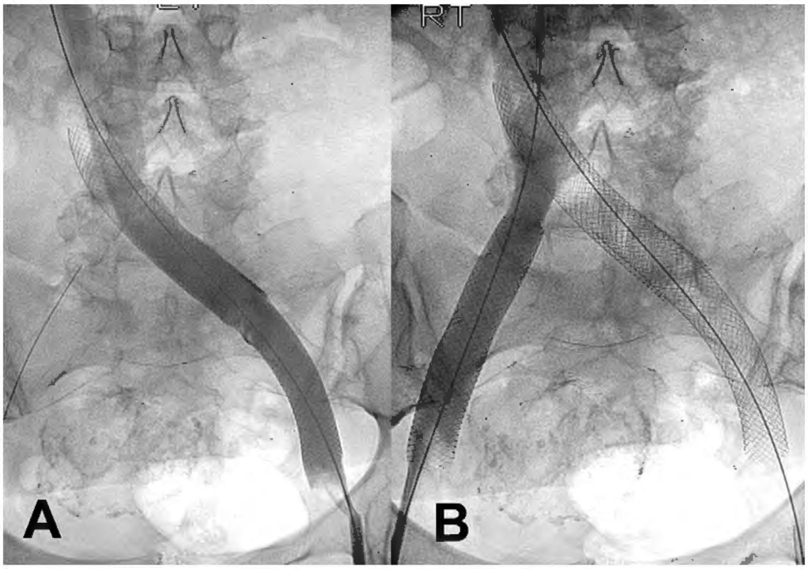

Fig 5. Stenting of the iliocaval confluence is shown using the apposition technique. **A,** A unilateral stent is inserted well into the inferior vena cava. **B,** A contralateral stent is placed as close as possible to the side of the previously inserted stent. The unsupported area is clearly shown, with good outflow through the side of the initially placed stent.

Table I. CEAP classification of the limbs treated with the three different techniques of stenting of the iliocaval confluence

	Group		
Variable	*Apposition* *n = 76*	*DB* *n = 78*	*iY* *n = 76*
Clinical class, No.			
C_2 (varicose veins, pain ≥5)	5	7	2
C_3 (venous edema)	40	46	37
C_4 (dermatitis, hyperpigmentation)	15	11	18
C_5 (healed ulcer)	4	2	5
C_6 (active ulcer)	12	12	14
Etiology, No.			
Primary (NIVL)	45	56	40
Postthrombotic	31	22	36
Anatomy, No.			
Deep	41	46	37
Deep/perforator	0	2	0
Deep/superficial	34	29	33
Deep/superficial/perforator	1	1	6
Pathology, No.			
Obstruction	33	38	33
Obstruction/reflux	43	40	43

DB, Double-barrel; *iY,* inverted Y fenestration*; NIVL,* nonthrombotic iliac vein lesion.

present in 68 of the postthrombotic limbs, and 21 limbs were occluded and required recanalization before stenting.

The CEAP classification of the stented limbs is reported in Table I. Limbs in class C_2 were treated because of severe pain and in C_3 because of grade 3 venous edema. The C_{4-6} rate was significantly greater in group iY than in group DB (49% and 32%, respectively; P = .049), but not when compared with group A (49% and 41%, respectively; P = .415). Group DB had a significantly greater ratio of limbs with NIVL than group iY (2.5/1 and 1.1/1, respectively, P = .022), but this was not significantly different compared with group A (2.5/1 and 1.5/1, respectively, P = .141). The frequency of limbs with reflux and of limbs with involvement of the superficial system was the same in the three groups.

Bilateral stenting was performed in 28 of 115 patients (24%) at the same procedure. For obvious technical reasons, this was more frequent in group DB than in groups A and iY (54%, 9%, and 11%, respectively; $P < .001$). However, patients in groups A and iY were more often intentionally staged than those in group DB (58%, 47%, and 18%, respectively; $P < .001$). The median time interval to the contralateral stenting was 3 months (range, 1-9 months).

Significant symptoms subsequently developed in the limbs of 40 patients with asymptomatic lesions of the contralateral iliac vein. This was due to progress of the local lesion and was not related to an acute thrombotic event involving the previously inserted stent. It is uncertain whether the jailing of the outflow after unilateral stenting results in accelerated progression of lesions, but this is unlikely because the rate of unintentional staging of contralateral stenting is rare. The clinical condition required stenting at a median of 11 months (range, 2-108 months) after the first procedure.

The three techniques were applied with the same frequency at the time of the nonintentional staging. The time interval to the use of different types of confluence stenting is shown in Fig 6. The more delayed the second stenting was, the more frequently inverted Y fenestration was used.

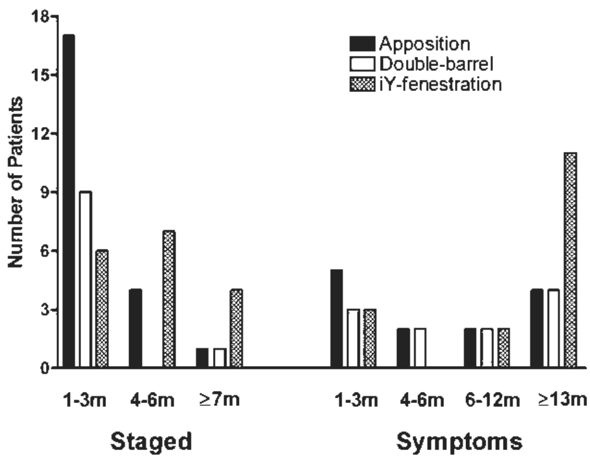

Fig 6. The type of stent technique used at the iliocaval confluence and the time interval between the initial and second procedure in patients with intentionally staged procedures *(Staged)* and in those who underwent a second stenting owing to development of symptoms in the contralateral lower limb (*Symptoms*). *iY,* inverted Y fenestration.

The median follow-up was 12 months (range, 1-108 months) in 107 patients (93%). During this time, occlusion of a stented area occurred 3 months to 7 years after primary stenting in four patients in group iY treated for postthrombotic obstruction. The stent system occluded bilaterally in one patient, and patency could not be restored. This patient had undergone an initially successful recanalization and stenting of a postthrombotic occlusion of her infrarenal IVC and both iliac veins. Another physician discontinued her anticoagulation therapy because of symptoms suggestive of gastrointestinal bleeding, and it was never restarted.

Three patients had unilateral iliac vein stent occlusion, which did not affect the stented IVC and contralateral iliac vein, and two were successfully reopened by pharmacomechanical thrombolysis. In addition, 29 reinterventions were performed of nonobstructive stent malfunctions (Table II). Limbs in group DB had significantly lower frequency of reinterventions than limbs in groups A and iY (8%, 32%, and 37%, respectively; $P < .01$).

Caudad de novo stenosis, which required distal extension of the stent system, was observed in the limbs of all groups. The most common procedure in limbs treated with the apposition technique was proximal extension covering the area between the previously inserted stents that were not covered at the primary procedure (8 limbs). In five limbs, the extension necessitated a fenestration and an inverted Y conversion was performed. In three limbs, it was possible to insert a stent and create a double-barrel configuration. The most common intervention in limbs with the inverted Y fenestration was balloon dilation and distal extension. In two patients, fenestration of the jailed stent limb was performed to improve the venous outflow.

The overall primary, assisted primary, and secondary patency rates for the bilateral stent system at 4 years were

Table II. Reinterventions performed because of nonobstructive stent system malfunction in 27 patients during the follow-up period

	Group		
Reintervention	*Apposition (n = 38)*	*DB (n = 39)*	*iY (n = 38)*
Proximal stent extension only, No.	3	0	1
+ distal stent extension	4	0	1
+ dilation	0	1	2
+ dilation and distal stent extension	1	0	0
Distal stent extension only, No.	1	2	3
Dilation only, No.	2	0	5
+ stenting of distal skip area	1	0	0
Fenestration of jailed limb, No.	N/A	N/A	2
All, No.	12	3	14

DB, Double-barrel; *iY,* inverted Y fenestration; *N/A,* not applicable.

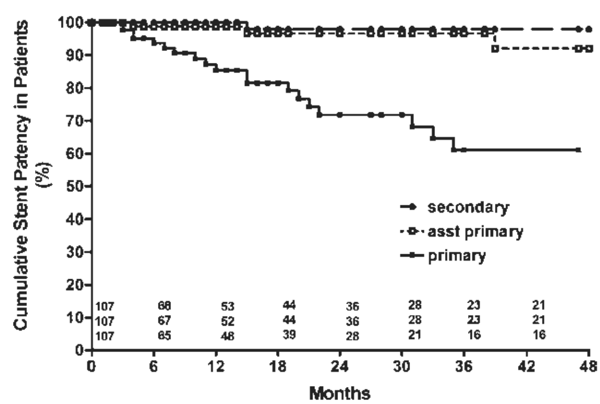

Fig 7. Cumulative primary, assisted primary, and secondary patency rates are shown for 107 patients with a bilateral stent system. The lower numbers represent limbs at risk at each time interval (all standard of means <10%).

61%, 92%, and 98%, respectively (Fig 7). The patients in group A who were converted to double-barrel or inverted Y configurations were censored at the time of conversion. The distribution of occluded stent system and frequency of reinterventions are reflected in the primary and secondary patency rates for groups A, DB, and iY at 4 years of 77% and 100%, 73% and 100%, and 41% and 90%, respectively (Fig 8). There was no significant difference between groups A and DB, but primary and secondary patency rates were significantly lower in group iY than in the other groups (log-rank test; $P < .001$ and $P = .007$, respectively).

The effect of severity (occlusion vs nonocclusive obstruction), etiology of obstruction (thrombotic vs nonthrombotic), and staging of the procedure was assessed. The patients with occlusive lesion were all in group iY. When patients treated for occlusive lesions were removed, the primary and secondary patency rates increased to 53% and 100%, respectively. The secondary patency was then the same in all treatment groups, but the primary patency

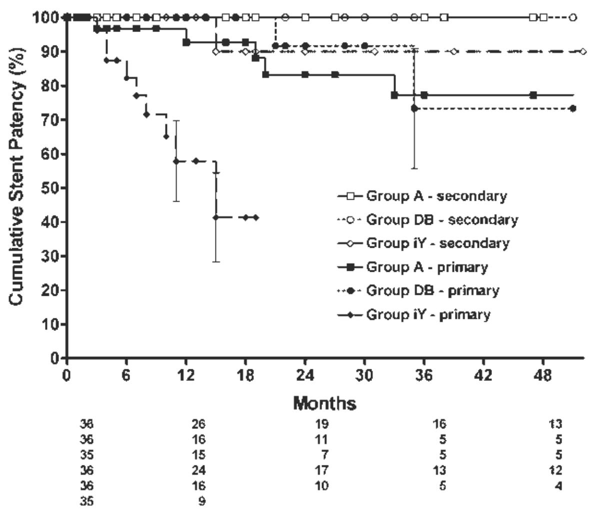

Fig 8. Cumulative primary and secondary patency rates of bilateral stent systems in groups undergoing apposition *(A)*, double-barrel (*DB*), and inverted Y fenestration *(iY;* see text for definition). The lower numbers represent bilateral stent system at risk at each time interval (standard of means >10% are shown by the *error bars*).

rate remained significantly lower in group iY than in the other groups.

In an effort to make these techniques more comparable, a further analysis was performed only in patients with nonocclusive obstruction and their patency rates were compared. Primary patency rates for the methods were compared by multiple logistic regressions while adjusting for etiology and whether the procedure was staged. Assisted primary and secondary patency rates were not analyzed because only one occluded patient achieved either of these types of patency. Preliminary analyses suggested that interaction terms were insignificant ($P > .25$ in each case), and etiology and staging also did not contribute to the model ($P = .4467$ and $P = .5454$, respectively). The final logistic regression model suggests primary patency rates are significantly different between DB and iY (odds ratio [OR], 4.35; 95% confidence interval [CI], 1.03-18.45; $P = .0460$) and between DB and A (OR, 4.94; 95% CI, 1.24-19.76; $P = .0238$), and not significant between A and iY (OR, 0.88; 95% CI, 0.29-2.63; $P = .8196$). This indicated that group DB had higher primary patency than groups A and iY, regardless of etiology or staging of the procedure.

The clinical outcome is not dependent on the type of stenting technique at the confluence as long as the stent remains widely patent, but reflects associated venous pathology. The clinical results are summarized in groups DB, A, and iY by complete relief of pain (85%, 86%, and 71%) and swelling (40%, 46%, and 42%), as well as by the ulcer healing rate (62%, 50%, and 43%) at the last follow-up. The clinical outcome is similar in the three groups, with some deterioration in group iY that probably reflects the increasing rate of limbs stented for postthrombotic disease with more complex disease in the groups DB, A, and iY (28%, 41%, and 48%, respectively).

DISCUSSION

Clinical and stent outcomes after unilateral femoroiliocaval stenting have previously been well described.[2-5] The inverted Y fenestration technique of stenting of the iliocaval confluence has previously been mentioned, but without technical details, in two previously published studies describing recanalization and stenting of the occluded iliocaval venous outflow[16] and obstruction of the IVC,[14] respectively. The use of the double-barrel and apposition techniques in the venous system has not previously been described. Unlike the previous studies, this study describes in detail the three techniques, compares the stent outcome of different techniques, and gives recommendations how to select the appropriate technique.

The results of this study suggest that chronic iliocaval confluence obstruction in patients with bilateral symptoms is best managed by bilateral stenting in a double-barrel fashion when technically feasible. This technique had 100% cumulative secondary patency rate at 4 years, the fewest reinterventions, (8%), and no late stent occlusions. Double-barrel placement is facilitated because the right and left common iliac veins have the same diameter at the confluence, which allows the same sized stents to be placed. It is important to oversize the stents to fill the lumen of the IVC. The stents in the IVC create a figure of eight crosscut area. Space outside the stent, which may be a concern at arterial bifurcations, does not seem to create a problem at the venous confluence.

However, the double-barrel technique can only be used when the caval obstruction is limited to the distal infrarenal IVC (<3 to 5 cm) or when bilateral lesions of the iliac veins adjacent to the confluence require stent extension into the IVC. The double-barrel stents should be placed in the same setting. Delayed placement of the second stent in the double-barrel configuration is discouraged, because it frequently compresses and deforms the initially placed iliocaval stent and compromises the outflow from that limb.

This technique is successful when the previously inserted stent only protrudes into the caval lumen and does not reach the contralateral caval wall. This placement allows easy passage of a stent from the contralateral side and a double-barrel placement performed with elongation of the previously placed stent by adding a cephalad stent. The healthy IVC is usually very compliant and will accommodate two parallel stents. A nonocclusive postthrombotic contracted IVC with dense wall fibrosis may recoil, despite high-pressure dilation, and not allow double-barrel stent placement.

Although the apposition technique had excellent secondary patency rate and no stent occlusions, reinterventions were required at a high rate (32%). The unsupported skip area between the stents inherent in this technique often developed a restenosis and required additional stent placement. This has been previously described to occur in interposed bare areas of vessels left uncovered and unsupported in both the arterial and venous systems.[20,21] The proximal additional stents in fact converted the appositioned stents into an inverted Y fenestration or double-barrel configuration.

The inverted Y fenestration technique is the only one of the three described techniques that can be used when a jailing contralateral iliocaval stent has previously been placed or when bilateral iliac vein stenting is necessary in the presence of extensive cephalad caval obstruction (>5 cm). It has the poorest stent-related outcome, with 11% late occlusions and a 37% reintervention rate. This may be due to the technique but is also related to the frequent presence of postthrombotic disease in these patients (48%). Stent patency rates and development of in-stent recurrent stenosis have previously been shown to be most significantly related to the presence and severity (occlusive or nonocclusive obstruction) of postthrombotic disease.[5,15]

An alternative to fenestration in cases with extensive obstruction of the IVC has been described.[17] A large-diameter stent (at least 24 mm) is placed like a funnel in the IVC, with its lower end at the confluence. Two iliocaval stents are then inserted into the funnel proximally with the double-barrel technique as described in this article. A systematic outcome evaluation of this technique has not been published. It was not used in this study.

Techniques to treat bifurcation lesions using nitinol stents have been described in detail by Sze et al.[22] These authors describe the alternative methods to cover bile duct branching, arterial bifurcations, and confluences in the venous system. It is well known that experience from stenting in the arterial system is not necessarily transferable to the venous circulation.[16,23] There are several examples of this observation. Unilateral iliocaval stenting across the iliocaval confluence can be performed without using the kissing-balloon technique. Jailing (stenting over branch orifices) of arterial branches, such as the internal iliac artery, coronary, or cerebral arteries, can be deleterious. With the inverted Y fenestration technique, the iliac venous outflow of one limb is "jailed" by the second stent, which is not routinely fenestrated.

Our extensive previous experience with unilateral iliocaval stenting in which the contralateral outflow is routinely jailed has minimal consequences.[5] The NIVL caused by iliac vein compression and intraluminal webs or postthrombotic obstruction is different from the arteriosclerotic occlusive lesion. It requires and accepts high-pressure dilation (up to 18 mmHg) with large balloon and stent sizes (16 to 20 mm diameter) without clinical rupture.

No study comparing the use of braided stainless steel stent and a nitinol mesh stent at the iliocaval confluence has been reported. We favor the use of the braided stainless steel stent because of its greater radial force, stiffness, diameter size (≥16 mm), and the theoretic advantage of braiding that prevents crushing of the stent by allowing longitudinal movement and less axial force underneath focal pressure points, which are unique to the venous system.[1] Despite the greater radial strength and stiffness of these stents, the external compression is occasionally so firm that additional balloon-expandable stents may have to be inserted at pressure points or at angles with a tendency to kink. It is not known what happens to the property of the stents when they are fenestrated. The nitinol mesh stent appears to fracture, whereas the braided stainless steel stent appears to be deformed. The proximal focal compression points at the confluence are closed to the site of fenestration and may be less controlled owing to loss of radial force due to local structural deformation at that site.

A major limitation of the comparison of the stenting techniques in this study is that the techniques are not always interchangeable, but are applied differently, dependent on the extent, degree, and anatomic site of the obstructive lesion, as well as the extent of previous unilateral stenting in staged cases. The stent-related outcome may certainly be affected by these factors and by whether the obstruction is postthrombotic or the procedure is staged. Stratifying the subsets of the different techniques to analyze these effects results in an insufficient number of patients for adequate statistical comparison for assisted primary and secondary patency.

The comparison of stent outcome in patients with similar type of nonocclusive lesions suggests that the fenestration technique has a lower primary patency rate (requires more frequently additional procedures) regardless of etiology of the obstruction or staging of the procedure and that occlusive postthrombotic obstruction may result in a lower rate of secondary patency. Further studies are necessary to elucidate these relationships.

CONCLUSION

Our preferred treatment of bilateral iliac nonthrombotic occlusive disease involving the iliocaval confluence is to perform one-stage double-barrel stenting. In patients with bilateral postthrombotic nonocclusive or occlusive disease, the technique is largely dependent on the extent of the disease in the IVC. With limited caudal involvement of the IVC (<5 cm) and a normal, compliant IVC above the obstruction, insertion of stents in a double-barrel fashion is usually possible. With extensive involvement of the IVC (>5 cm) or a cephalad fibrotic and noncompliant IVC, doubling of the stent in the caval lumen is prohibited and an inverted Y technique with fenestration is performed. Appositional stents are only placed if fenestration fails. Presently, there is no optimal solution to the treatment of the iliocaval confluence. Development of modular stents with side ostia that allow placement without covering outflow from the contralateral side is necessary.

AUTHOR CONTRIBUTIONS

Conception and design: PN, SR
Analysis and interpretation: PN, SR, JO
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Writing the article: PN, SR
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