Stenting of chronically obstructed inferior vena cava filters

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Objectives: A protective inferior vena cava (IVC) filter may later be incorporated into a chronic postthrombotic ilio-caval obstruction (occlusive, requiring recanalization, or nonocclusive). This study aims to assess the safety and stent-related outcome following stenting across an obstructed filter.

Methods: From 1997 to 2009, 708 limbs had stenting for postthrombotic ilio-caval outflow obstruction (occlusion in 121 limbs). In 25 patients, an IVC filter was obstructed (Group X). The site was crossed by a guidewire and balloon dilated. The filter was markedly displaced sidewise or remodeled. A stent was placed across the IVC filter and redilated. In 28 other patients, the cephalad stenting terminated below a patent IVC filter (Group B). The remaining 655 patients had no previous IVC filter placement (Group no IVC filter present [NF]). The patients were followed to assess patency. The types of reintervention were noted.

Results: The stenting maneuver through a variety of previously inserted IVC filters was safely performed without an apparent tear of the IVC, no clinical bleeding or abdominal symptoms, or pulmonary embolism. Mortality was nil; morbidity minimal. The primary and secondary cumulative patency rates at 54 months for limbs with postthrombotic obstruction were with and without IVC filter (38% and 40%; $P = .1701$ and 79% and 86%; $P = .1947$, respectively), and for limbs with stenting across the filter (Group X) and stent termination below the filter (Group B; 32% and 42%; $P = .3064$ and 75% and 84%; $P = .2788$, respectively), not statistically different. When Group X alone was compared with Group NF, the secondary patency rate was, however, significantly lower (75% vs 86%; $P = .0453$), suggesting that crossing of the stent was associated with reduced patency. Occlusive postthrombotic disease requiring recanalization was more frequent in Group X than in Group B and Group NF (68%, 25%, and 15%, respectively; $P = .004$). A comparison was therefore performed only between limbs stented for recanalized occlusions with ($n = 23$) and without IVC filters ($n = 92$) showing no difference (cumulative primary and secondary patency rates 30% and 35%; $P = .9678$ and 71% and 73%; $P = .9319$, respectively). Multiple logistic regression analysis also supported a significant association between patency rate and occlusive disease (odds ratio, 6.9; 95% confidence interval, 3.4-13.9; $P < .0001$), but not between patency rate and presence of an IVC filter ($P = .5552$).

Conclusions: Stenting across an obstructed IVC filter is safe. It appears that patency is not influenced by the fact that an IVC filter is crossed by a stent, but is related to the severity of postthrombotic disease (occlusive or nonocclusive obstruction) and the associated recanalization procedure. (J Vasc Surg 2011;54:153-61.)

Percutaneous stenting of the femoro-ilio-caval venous outflow guided by intravascular ultrasound (IVUS) is presently the method of choice in the treatment of clinically significant chronic venous obstruction at this anatomical site. By consensus on terminology, an obstruction is defined as a partial or total blockage of the vein (ie, nonocclusive [stenosis] or occlusive [occlusion]).[1] It is not known at what degree a venous stenosis becomes hemodynamically significant.[2] Ilio-caval stenting of obstruction >50% has been reported to result in sustained relief of limb symptoms, high rate of healing of venous leg ulcers, and substantial improvement of quality of life and decreased disability, even in the presence of untreated reflux.[3-7] Chronic postthrombotic obstruction may be occlusive or nonocclusive and involve the ilio-caval vein segment. Permanent inferior vena cava (IVC) filters may have been placed to prevent fatal pulmonary embolism in the course of treatment of the acute thrombotic disease and subsequently thrombosed. When stenting is attempted in patients with an IVC filter incorporated in a chronic obstruction, it poses a special technical problem. To ensure an adequate outflow, the obstructed filter must be balloon-dilated and stented. Interventionists have been reluctant to dilate the filter-bearing segment for fear of tearing the IVC, fracturing or displacing filters, and increasing the risk for subsequent pulmonary embolism (PE). This study aims to assess the safety of stenting of a chronically obstructed IVC filter in patients with postthrombotic disease and whether or not IVC filter stenting influences the stent-related outcome.

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MATERIAL AND METHODS

A review of a venous stent database of patients having had femoro-ilio-caval vein stent placement with informa-

Fig 1. Left, Venogram showing a thrombosis of a previously placed inferior vena cava (IVC) filter and stented ilio-femoral veins below. Collateral circulation through the ascending lumbar veins filling the normal IVC above the occluded filter is visualized. **Right,** The IVC filter is incorporated in a balloon dilation of the ilio-caval segment, remodeled and then stented across. Venogram shows unobstructed venous outflow.

tion collected prospectively in a predetermined protocol in a time-stamped database from January 1997 to June 2009 revealed 708 patients with stenting for chronic nonmalignant postthrombotic ilio-caval outflow obstruction, including recanalization of occlusion in 121 patients. Patients with acute or acute/chronic lower limb thromboses requiring thrombolysis before stenting were excluded. The obstructive lesion was considered postthrombotic when the patient had a known occurrence of deep vein thrombosis diagnosed with duplex ultrasound or ascending venogram and had subsequently been treated by anticoagulation, or findings on venogram (occlusion, stenosis, or collaterals) and/or duplex ultrasound indicating previous deep vein thrombosis below the inguinal ligament (direct visualization of thrombus or indirect indication by partial or total inability to compress the vein). An IVC filter had previously been inserted in 53 patients. In 25 patients, the IVC filter was incorporated into an occlusive or nonocclusive obstruction and traversed by a stent (Group X = across; Fig 1). An IVC filter was found in a patent IVC cephalad to an obstructed ilio-femoral venous segment in 28 patients (caval involvement in only one patient), which was subsequently stented. In these patients, the balloon dilation and stent placement did not involve the IVC filter site (Group B = below; Fig 2). The remaining 655 patients had no previous IVC filter placement (Group NF = no filter). In 103 of these patients, the IVC was involved in the postthrombotic obstruction. In the remaining patients, the cephalad extension of the postthrombotic obstruction included the common iliac vein, but not the IVC.

All limbs were classified using the CEAP classification according to the Reporting Standards of the International Society of Cardiovascular Surgery/Society of Vascular Surgery,[8,9] based on duplex ultrasound study with standardized compression and clinical symptoms.[10,11] The patients were routinely surveyed at 3, 6, and 12 months poststenting and then annually with transfemoral/ascending venography or duplex ultrasound to assess patency. Patency was defined as visible flow throughout the entire stent system. Reintervention was performed because of symptomatic or asymptomatic stent malfunction (ie, stent occlusion, more than 50% in-stent stenosis, visualization of collaterals, and inflow or outflow abnormalities found on routine surveillance in the stented IVC and/or the stented iliac limb). Intervention was performed in the majority of cases based on transfemoral venography, which was obtained when ultrasound suggested stent malfunction. Type and frequency of reinterventions were noted. Although the main endpoint of this study is not clinical outcome, some perioperative symptomatic outcomes are given. The study endpoint of legs with stasis ulceration was complete epithelialization. The degree of pain was evaluated perioperatively using a visual analog scale from 0 to 10, wherein 10 is 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) as per 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.[7,13-18] Ultrasound-guided venous access was performed of the common femoral, femo-

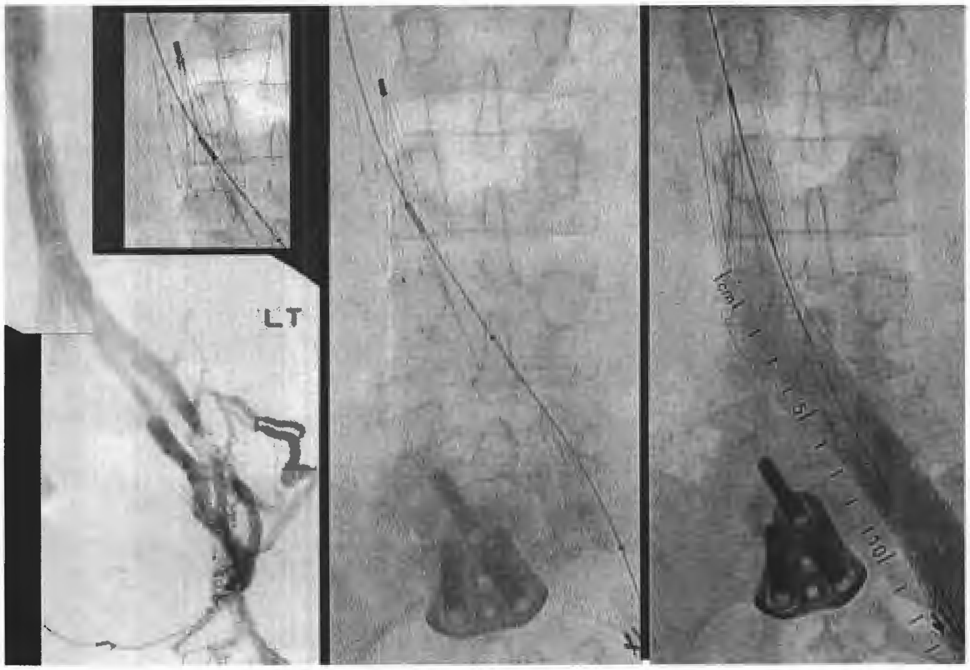

Fig 2. Left, Venogram showing left postthrombotic iliofemoral vein obstruction with previously placed inferior vena cava (IVC) filter (*inset*). **Middle,** The obstruction and filter are traversed by a guidewire and intravascular ultrasound (IVUS) has shown no stenosis or thrombus. **Right,** The caudad obstruction has been dilated and stented. The cephalad termination of the stent is below the untouched IVC filter.

ral, or popliteal vein under general anesthesia. The presence of an obstructed IVC filter did not change the previously described stenting technique used to treat femoro-iliocaval vein obstructions. A guidewire was placed across the obstruction (occlusive or nonocclusive), and subsequently venoplasty and stenting were performed. Occlusions required recanalization with a 0.035" soft or stiff Glidewire (Terrumo Inc, Somerset, NJ) as previously described in detail in an earlier publication (Fig 3).[17] When the IVC filter was not occluded, the guidewire usually passed with ease. The degree of stenosis at the site of IVC filter placement was then evaluated by IVUS. A >50% stenosis at the filter site was considered significant and was treated. Both nonocclusive and occlusive obstructions were always dilated prior to stent placement (Fig 4). Large high-pressure balloons (18-24 mm diameter) reaching 16 to 18 atm pressure were routinely used. The filters were displaced sideways or remodeled/fractured depending on the type of filter, including those with prongs, by repeated high-pressure balloon dilation to allow the stent placement (Fig 5). An appropriately sized stent (16-24 mm diameter) was placed across the IVC filter and redilated. In this study, only braided stainless steel stents (Wallstents; Boston Scientific, Natick, Mass) were used. All diseased segments, as identified by IVUS, were covered by the stent to ensure adequate inflow and outflow of the stent. In pursuit of these principles, the stent system was extended across patent renal veins, across contralateral iliac veins, and below the inguinal ligament when necessary. If the IVC filter site was not obstructed, the cephalad termination of stenting was below the filter. All stented patients with previously inserted IVC filters were fully anticoagulated for life. No IVC filter was reinserted in any case, since there was no permanent contraindication to anticoagulation.

STATISTICS

Categorical variables were analyzed by Fisher's exact test. Primary and secondary patency rates as defined by the reporting standards of the International Society of Cardiovascular Surgery/Society of Vascular Surgery[8] were calculated using survival analysis with the Kaplan-Meier survival curve method. The log-rank test was used to compare cumulative curves. Results are reported using *P* values. A *P* value of less than .05 was considered significant.

The association between the outcome variable patency and possible explanatory variables filter (no filter with and without IVC involvement, unstented filter, and stented filter) and severity of postthrombotic disease (occlusive and nonocclusive disease) was assessed through multiple logistic regression. Within the framework of this model, potentially confounding variables, including gender, operation side, and age were also assessed. *P* values for main effects less than 0.05 and interactions less than 0.20 were considered statistically significant. Commercially available statistical programs (GraphPad Prism for Windows [version 3.0];

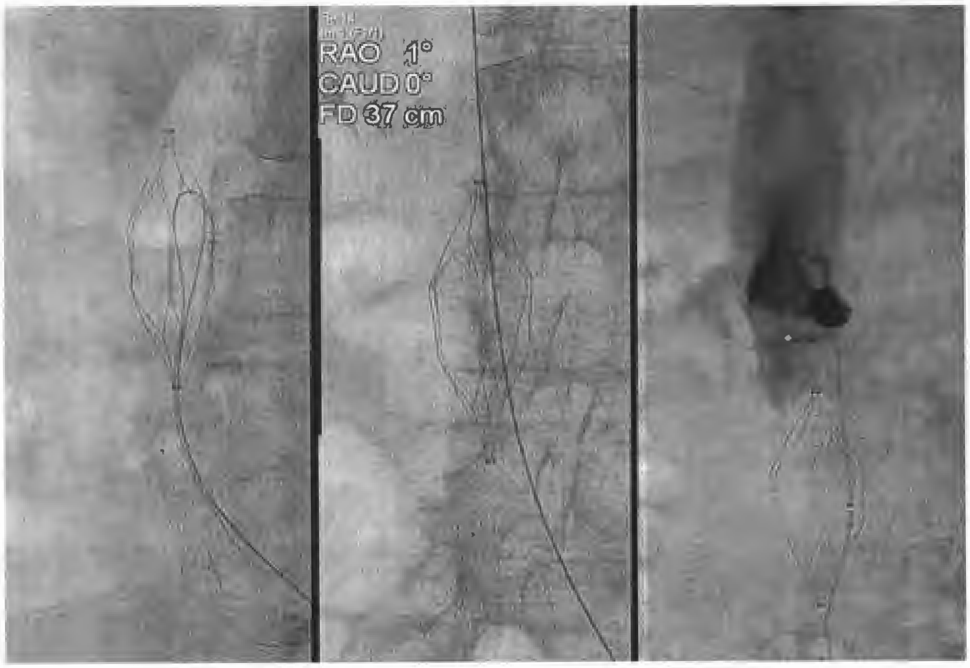

Fig 3. Left, The occluded inferior vena cava (IVC) filter is recanalized using the same technique as for the caudad venous occlusion by using a soft or semi-stiff Glidewire. Once the correct plane has been entered, rapid progress can usually be achieved without perforation by developing a loop or supporting a soft wire with a catheter during manipulation. **Middle,** The guidewire has been pushed across the occluded stent. **Right,** A small guiding catheter has been placed with its tip above the obstruction, and the correct position is checked by an injection of dye.

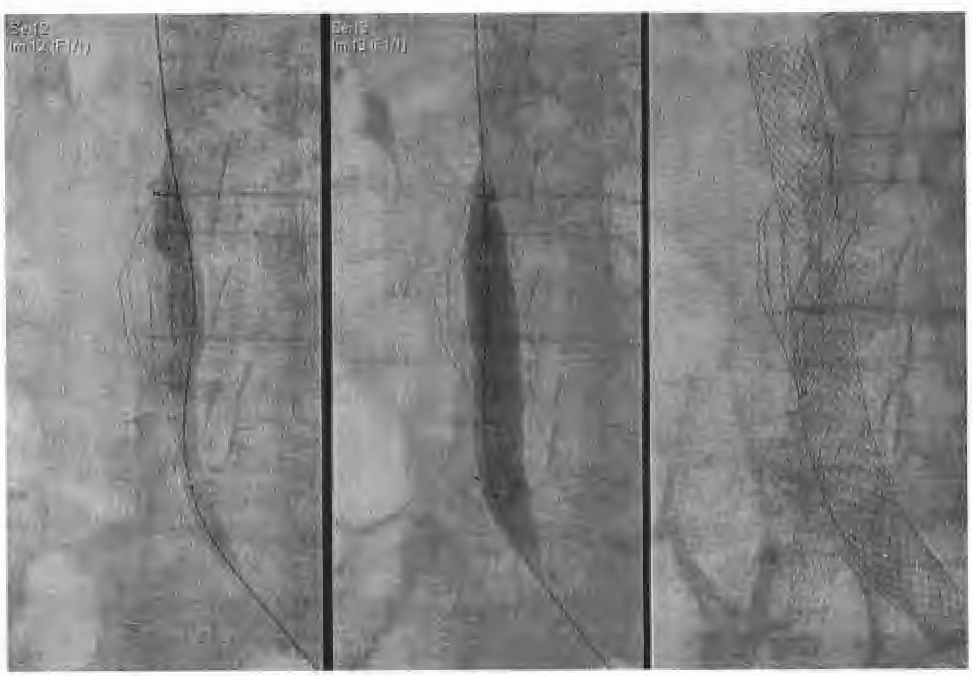

Fig 4. Left, Predilation is performed using a smaller balloon. **Middle,** The channel that is created allows passage of a wider (16-18 mm) high-pressure balloon (inflated to 16-18 atm), which is used to markedly remodel the inferior vena cava (IVC) filter. **Right,** A stent can now be placed across the IVC filter and is then redilated with the high-pressure balloon.

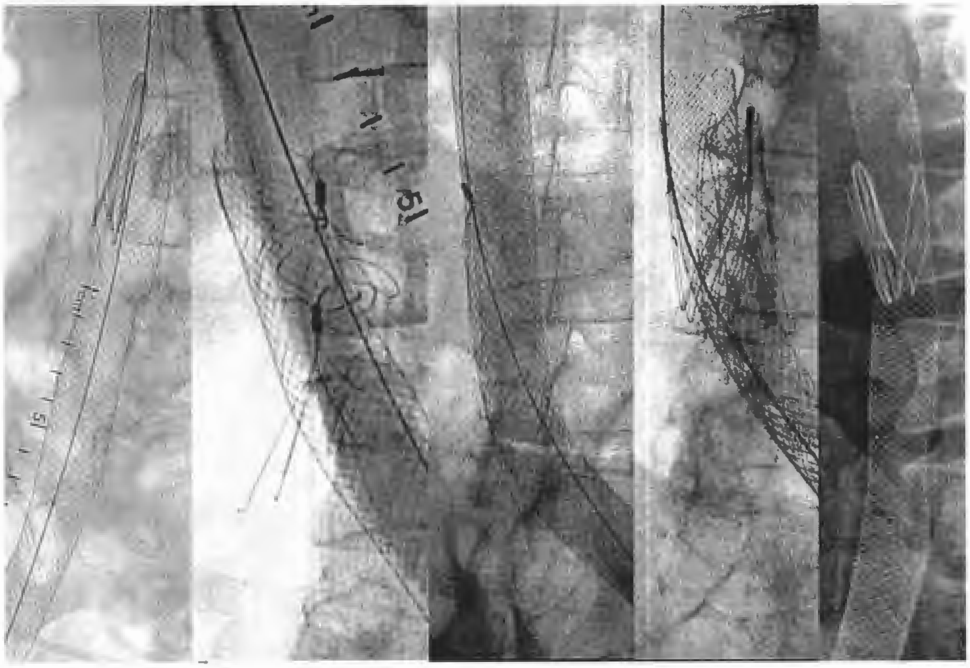

Fig 5. Five examples of stented inferior vena cava (IVC) filters with and without prongs, which have been remodeled, crushed and displaced sidewise, and/or fractured.

GraphPad Software, La Jolla, Calif and SAS [version 9.1.3], SAS Institute, Inc, Cary, NC) were used for analysis.

RESULTS

Femoro-ilio-caval stenting was performed in 53 patients with postthrombotic obstruction and previously inserted IVC filters (7.5%; 53 of 708). Approximately half had stenting performed through the IVC filter (Group X; n = 25) and half had cephalad stenting ending below an intact IVC filter (Group B; n = 28). Recanalization of any occlusion may be a challenging procedure and may at first sight appear impossible to achieve, but it is successfully performed more often than not. Only one occluded filter could not be recanalized and traversed by the guidewire. This was the only Mobin-Udin "umbrella" encountered in this study and had been placed 20 years prior to the recanalization attempt. This patient was excluded from the study. The types of IVC filters found in stented patients are listed in Table I. The obstructed IVC filters were placed 4 months to 20 years (median, 4 years) prior to the recanalization. The obstruction of the stented IVC filters was occlusive in 17 (68%) and nonocclusive in eight (32%). Occlusive postthrombotic disease requiring recanalization was more frequent in Group X than in Group B and Group NF (68%, 25%, and 15%, respectively; $P < .001$).

The age distribution in the three groups of patients with postthrombotic disease of the lower limbs treated by stenting of the iliac venous outflow with and without previously inserted IVC filters was similar (median, range; 54 years, 29-92 years; 50 years, 23-91 years; and 54 years, 18-87 years; Groups X, B, and NF, respectively). The male/female ratio was greater in Groups X and B than in Group NF (1.8:1, 1.3:1, and 0.5:1, respectively, $P = .0009$). The left lower limb was involved in 68%, 52%, and 62% of limbs in Groups X, B, and NF, respectively ($P = .4816$). The CEAP classification of the symptomatic leg is given in Table II. The C-class distribution (C_{4-6}) tended to be higher in Groups X and B, but there was no statistical difference between the three groups. The proportion of patients with significant symptoms of pain (visual analog scale ≥5/10) was also similar (46%-56%). The frequency of limbs with presence of reflux was also similar in each group. The combination of deep, superficial, and perforator reflux (pan reflux) was significantly greater in Group X than in Groups B and NF (24%, 7%, and 6%, respectively, $P = .006$), but the other combinations of reflux had no significantly different ratios.

Table I. Type of IVC filter found in patients with femoro-ilio-caval stenting (n = 53)

Type of IVC filter	*Group X (n = 25)*	*Group B (n = 28)*
Greenfield filter	11	21
Recovery G2	6	1
Simon nitinol	3	1
Vena Tech	2	0
Bird's nest	1	2
TrapEase	1	2
Gunther tulip	1	1

IVC, Inferior vena cava.

Table II. CEAP classification of postthrombotic limbs with and without IVC filters treated by femoro-ilio-caval stenting

	Group X (*n* = 25)	*Group B* (*n* = 28)	*Group NF* (*n* = 655)
Clinical Class			
C2	0	0	29
C3	11	13	325
C4	6	9	132
C5	2	2	36
C6	6	4	133
Etiology			
Postthrombotic	25	28	655
Anatomy			
Deep	8	10	283
Deep/perforator	1	1	19
Deep/superficial	10	15	314
Deep/superficial/ perforator	6[a]	2	39
Pathology			
Obstruction	5	5	185
Obstruction/reflux	20	23	470

IVC, Inferior vena cava.
Group B, stenting terminating below the IVC filter.
Group NF, no IVC filter present.
Group X, stented across the IVC filter.
[a]$P < .002$, group X vs groups B and NF.

Table III. Reinterventions performed because of stent system malfunction in postthrombotic limbs with and without IVC filters treated by femoro-ilio-caval stenting

	Group X (*n* = 25)	*Group B* (*n* = 28)	*Group NF* (*n* = 655)
Stent occlusion			
Early (<30 days)	3 (12%)	1 (4%)	22 (3%)
Late	3 (12%)	3 (11%)	45 (7%)
Reopened	3/6	2/4	7/67
Interventions in nonocclusive malfunction			
Dilation only	2	3	70
Dilation and additional stent	3	2	27
Additional stent only	4	3	43
All	9 (36%)	8 (29%)	140 (21%)

IVC, Inferior vena cava.
Group B, stenting terminating below the IVC filter.
Group NF, no IVC filter present.
Group X, stented across the IVC filter.

The IVUS investigation during the procedure revealed a thinner outline of hyperecogenicity of the vessel in cases with nonocclusive obstruction. The narrowing was either due to a moderate fibrosis and constriction of the vein wall at the filter site (perhaps an inflammatory reaction to the stent) and/or partial obstruction due to thrombus in the filter. Contrarily, the occluded veins were found to have a thicker layer of increased echogenocity surrounding the vein, suggesting marked postphlebitic fibrosis. High-pressure balloons were found to be especially useful in these situations. The balloon dilation and stent placement was performed safely without apparent tear of the IVC, subsequent clinical bleeding, or clinically symptomatic pulmonary embolism. Even extensive stenting of the IVC from the atrium to the confluence of the iliac veins did not appear to have any adverse affect on the splanchnic outflow. Mortality was nil. Morbidity was minimal; six patients had large hematoma/bruising, which did not require any intervention.

The number of patients followed up were: in Group X, 23 of 25 (92%); in Group B, 21 of 28 (75%); and in Group NF, 555 of 655 (85%); the median follow-up was 9 months (range, 2-62 months), 7 months (range, 2-102 months), and 8 months (range, 2-125 months), respectively. Occlusion rates and interventions for occlusive and nonocclusive stent system malfunctions are shown in Table III. The rate of postoperative (<30 days) thrombotic occlusion of the stent system tended to be increased, but was not statistically higher, in Group X than in Groups B and NF (12%, 4%, and 3%, respectively; $P = .0843$). The differences in these percentages appear large; however, post hoc power analysis resulted in a small effect size ($W = .085$) indicating sample size was not the determining factor in the statistical insignificance of this comparison.[19] Similarly, the late stent occlusion rate and rate of interventions for nonocclusive stent malfunction were statistically not different in the three groups (Groups X, B, and NF: 12%, 11%, and 7%, $P = .5636$; 36%, 29%, and 21%, $P = .1257$, respectively). Occluded stent systems were reopened by thrombolytic techniques and stayed patent in three patients in Group X, two patients in Group B, and seven patients in Group NF.

The distribution of occluded stent system and frequency of reinterventions are reflected in the primary and secondary cumulative patency rates at 54 months for limbs with postthrombotic obstruction with and without IVC filter (38% and 40%; $P = .1701$ and 79% and 86%; $P = .1947$, respectively; Fig 6), and for limbs with stenting across the filter (Group X) and stent termination below the filter (Group B; 32% and 42%; $P = .3064$ and 75% and 84%; $P = .2788$, respectively; Fig 7). Thus, the patency rates did not appear to be influenced by the presence of an IVC filter, and there was no statistically significant difference in patency rates whether or not the IVC filters were incorporated in the obstruction. However, when Group X alone was compared with Group NF, the secondary patency rate was significantly lower (75% vs 86%; $P = .0453$). A comparison between stenting of occlusive and nonocclusive obstruction in Group NF also revealed a significantly lower secondary patency rate in limbs with occlusion (73% and 89%; $P < .0001$, respectively). There was in this group, however, no difference in the secondary patency rate whether or not the IVC was involved (89% and 86%, respectively; $P = .3811$). Since the rate of occlusive disease requiring recanalization was significantly greater in Group X, a comparison was therefore performed between limbs stented for recanalized occlusions with (n = 23) and without IVC filters (n = 92; cumulative primary and secondary

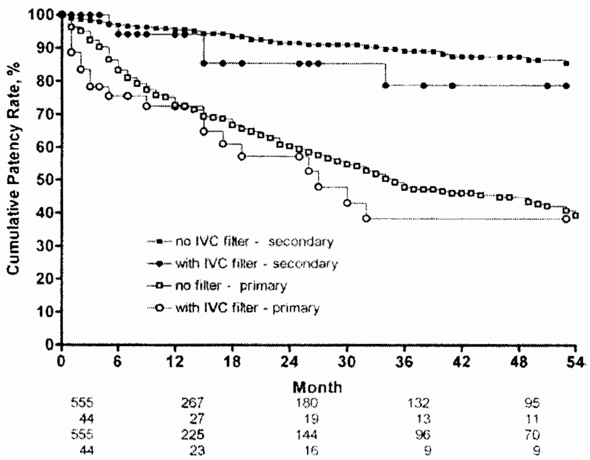

Fig 6. Cumulative primary and secondary patency rates of patients stented for postthrombotic obstruction with (n = 44) and without (n = 555) previously inserted inferior vena cava (IVC) filter. The lower numbers represent limbs at risk at each time interval (all standard error of means <10%).

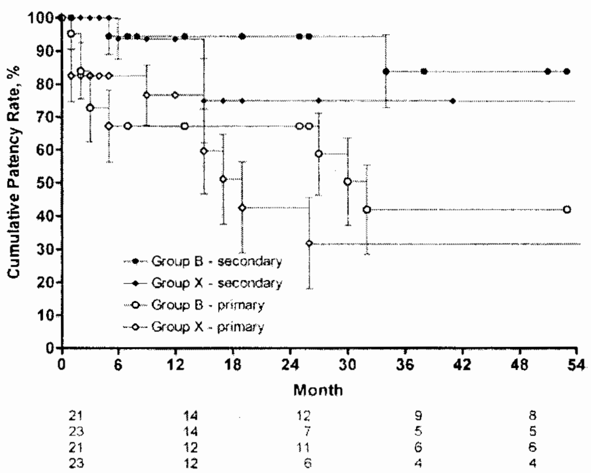

Fig 7. Cumulative primary and secondary patency rates after stenting of postthrombotic obstruction in Group B (stenting terminating below the inferior vena cava [IVC] filter) and Group X (stenting across the IVC filter). The lower numbers represent stented patients at risk at each time interval (standard error of means >10% are shown by placing *error bars*).

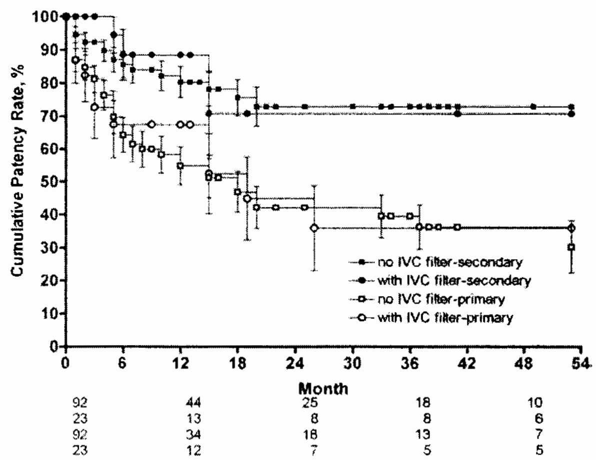

Fig 8. Cumulative primary and secondary patency rates after stenting of postthrombotic occlusion requiring recanalization, with (n = 23) and without (n = 92) previously inserted inferior vena cava (IVC) filter. The lower numbers represent stented patients at risk at each time interval (standard error of means >10% are shown by placing *error bars*).

patency rates, 30% and 35%; $P = .9678$, and 71% and 73%; $P = .9319$, respectively; Fig 8).

To further analyze the influence of the presence of an IVC filter and occlusive disease on stent patency, a multiple logistic regression was performed. This model also included gender, operation side and age as potential confounders (Table IV). The interaction between presence of the IVC filter and severity of disease was omitted because it was highly insignificant ($P = .9796$). The results from this analysis suggest a significant association between patency rate and occlusive disease (odds ratio, 6.9; 95% confidence

Table IV. Multiple logistic regression analysis of potential factors associated with stent patency (type 3 analysis of effects)

Factor	*Df*	χ^2 *Statistic*	P *value*
Presence of IVC filter	3	2.0840	.5552
Occlusive disease	1	29.3900	<.0001
Gender	1	0.8368	.3603
Sidedness	1	1.2493	.2637
Age	2	7.0355	.0297
Gender-sidedness	1	6.0683	.0138
Gender-age	2	5.3381	.0693

DF, Degree of freedom; *IVC*, inferior vena cava.

interval, 3.4-13.9; $P < .0001$), but not between patency rate and presence of an IVC filter ($P = .5552$). Neither the presence of an IVC filter nor occlusive disease significantly interacted with gender, operation side, or age.

Patency rates for all combinations of filter groups and severity of disease are given in Table V. Significance testing is not appropriate for assessing equivalence among the filter groups; instead, binomial confidence intervals for each unique group were computed. Owing to small sample sizes and the fact that several point estimates are at or near the boundary for probabilities, the score method of interval construction was utilized.[20]

The clinical outcome is not dependent on whether or not an obstructive IVC filter is included as long as the stent remains widely patent, but reflects associated venous pathology. The frequency of limbs with presence of reflux and combination of obstruction and reflux were similar in each group. The clinical results are summarized by complete relief of pain, swelling and ulcer healing rate at the last follow up in Group X and Group NF (85% and 77%; $P =$

Table V. Significance analysis of binomial confidence intervals for combination of IVC filter groups X, B, and NF and occlusive or nonocclusive postthrombotic disease

	Patent (n = 553)	*Occluded (n = 46)*	*Patency rate (95% confidence interval)*
Nonocclusive (n = 485)			
Group NF	443	21	0.95 (0.93, 0.97)
Group B	14	1	0.93 (0.70, 0.99)
Group X	6	0	1.00 (0.61, 1.00)
Occlusive (n = 114)			
Group NF	72	19	0.79 (0.70, 0.86)
Group B	5	1	0.83 (0.44, 0.97)
Group X	13	4	0.76 (0.53, 0.90)

IVC, Inferior vena cava.
Group B, stenting terminating below the IVC filter.
Group NF, no IVC filter present.
Group X, stented across the IVC filter.

.5650, 40% and 48%; $P = .4981$, 75% and 66%; $P = .7124$, respectively). These clinical parameters were not significantly different in the group of patients stented across an obstructive filter as compared with stented patients with no filter.

DISCUSSION

Obstruction of varying types of IVC filters may occur due to primary thrombosis of the filter or capture of large emboli. Permanent IVC filters have been reported to obstruct in up to 20% of patients.[21] Recent reports of varying institutional experience suggest filter obstruction to be less frequent (2%-5%).[22-24] Nonocclusive filter thrombus was found in 17% of patients, but only 20% of these created a more than 50% stenosis.[24] The factors causing IVC filter thrombosis are unclear. The distribution of types of IVC filters in this study in no way reflects the propensity of late occlusion of different types of permanent or removable filters. IVC filter design is probably important since, in other studies, opposed biconical devices appear to be associated with higher occlusion rates.[22,23]

A segmental obstruction of the IVC may not be markedly symptomatic, but the symptoms usually become severe when combined with an obstruction of the iliac vein segment caudad to the IVC.[15] When a clinically significant extensive ilio-caval obstruction involving the IVC filter site is encountered, the stent must be balloon-dilated and stented to ensure adequate outflow. Early clot removal and stenting through an occluded previously placed IVC filter in patients with acute thrombotic obstruction has been shown to be a safe procedure.[25] There was no clinically detectable pulmonary embolism (PE) and the stents remained patent in that study during a median follow-up of 9 months. In the targeted group of patients in this study, all had chronically obstructed IVC filters with involvement of the iliofemoral vein. The postthrombotic disease was severe with a combination of obstruction and reflux in 80% of patients and pan reflux in 24% of the limbs, accompanied by severe signs and symptoms (C-class of CEAP 4-6 and visual analog scale ≥5/10 in 56% and 47% of all limbs, respectively). Stenting through chronically occluded IVC filters has previously been mentioned, but lacking detailed analysis, in two previously published studies describing recanalization and stenting of the occluded ilio-caval venous outflow[17] and obstruction of the IVC.[15] Unlike these studies, the present study describes in more detail the technique and patency rates and also evaluates whether or not a stenting through an obstructed IVC filter affects patency.

The results of this study show that stenting across a chronically obstructed IVC filter is safe. It was performed with no mortality and minimal morbidity, regardless of occlusive or nonocclusive obstruction. No apparent or clinically relevant tearing of the IVC, clinical retroperitoneal hematoma, or abdominal symptoms occurred despite substantial remodeling, fracturing, and displacement of the filter. There were no clinical signs of PE during the follow-up. The absolute postoperative stent occlusion (within 30 days), late stent occlusion, and reintervention rates were not different whether or not an IVC filter was present or, when present, crossed by a stent. More interestingly, the cumulative patency rates were the same in stented patients with or without an IVC filter. A comparison between patients with IVC filters crossed and those with stent termination below the existing filter indicated no difference in patency rates.

The cumulative patency rate was, however, decreased significantly in patients with filters crossed by stents (Group X) as compared with patients with no filters at all (Group NF), suggesting that crossing of the stent was a risk factor for reduced patency. It has previously been shown that the major risk factors for late stent occlusion are the presence of postthrombotic obstruction and severity of postthrombotic disease (occlusive vs nonocclusive obstruction).[26] This explains the lesser cumulative patency rate in patients stented for occlusion in the nonfilter group. When patients with nonocclusive obstruction (stenosis) were excluded, the cumulative patency rates in patients with occlusive postthrombotic disease with or without previous IVC filer insertion were the same. Contrary to the severity of obstruction, neither sidedness nor gender has previously been shown to be associated with stent occlusion.[26] All patients in this study had obstructive postthrombotic disease, but Group X had a higher rate of occlusive disease requiring recanalization. Group X also contained more males and displayed an even distribution between left and right lower limbs, which was different from the other groups. This may potentially affect the observed differences in patency rates. A multiple logistic regression analysis was therefore performed. It supported a strong association between patency rate and occlusive disease, but none between patency rate and presence of an IVC filter. Potential confounders such as gender, sidedness, and age may affect stent patency rates individually or in combinations. However, the effect by the confounders on the nonsignificant association between patency and presence of IVC filter was minimal. In addition, these confounders cannot explain the significant relationship between patency and severity of disease. It appears that patency is not influenced by the fact that an IVC filter is crossed by a stent, but is related to the severity of post-thrombotic disease (occlusive or nonocclusive obstruction) and the associated recanalization procedure.

The main limitation of this study is the sample size in Groups X and B. Sample size is always an issue when interpreting any results. Although additional statistical analysis was performed suggesting that sample size was not the determining factor, caution should be expressed whenever declaring means/proportions equivalent or different. The analysis was per se retrospective, but the data that were analyzed were prospectively collected in a time-stamped preset electronic record. The clinical value of stenting of an obstructed IVC filter is not expressed by the patency rates. The clinical outcome was not assessed in detail in this study. However, complete relief of pain and swelling and the ulcer healing rate was not significantly different in the group of patients stented across an obstructive filter as compared with stented patients with no filter.

There is no reason to believe that the clinical outcome would be different than previously reported results of stenting of femoro-ilio-caval obstruction without IVC filter involvement.

In conclusion, when a previously inserted IVC filter is incorporated into a postthrombotic obstruction, the filter-bearing segment may be safely balloon dilated and stented with no deleterious effect on stent patency.

AUTHOR CONTRIBUTIONS

Conception and design: PN, SR
Analysis and interpretation: PN, SR JO
Data collection: PN, MO, SR
Writing the article: PN, JO
Critical revision of the article: PN, JO, SR
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