Eur Respir J, 1996, 9, 2012–2016
DOI: 10.1183/09031936.96.09102012
Printed in UK - all rights reserved

European Respiratory Journal
ISSN 0903 - 1936

Symptomatic inferior vena cava filter thrombosis: clinical study of 30 consecutive cases

B. Tardy*, P. Mismetti**, Y. Page*, H. Décousus**, A. Da Costa+, F. Zeni*, G. Barral++, J.C. Bertrand*

Symptomatic inferior vena cava filter thrombosis: clinical study of 30 consecutive cases. B. Tardy, P. Mismetti, Y. Page, H. Décousus, A. Da Costa, F. Zeni, G. Barral, J.C. Bertrand. ©ERS Journals Ltd 1996.

ABSTRACT: Inferior vena cava (IVC) filter thrombosis has not been described as a clinical entity. Thirty patients with IVC percutaneous filter thrombosis were assessed by cavography, computed tomographic (CT) scan and/or duplex ultrasonography.

All patients had proximal venous thrombosis when the filter was placed, and the indication for filter placement was a contraindication to anticoagulant therapy in eight patients (27%). Filter thrombosis occurred within 6 months following filter placement in 15 patients (early filter thrombosis group). Among these patients, 10 were not treated with oral anticoagulant, and none of the other five received adjusted anticoagulation. No patients with late filter thrombosis received anticoagulant at the time of the diagnosis. Early filter thrombosis was mainly associated with LGM filters (12 of the 15 cases). Occlusion was revealed by recurrent venous thrombosis in 18 cases. A thrombus above the filter and pulmonary embolism was found in 10 patients (33%). Thrombolytic therapy failed in 5 out of 7 cases, and all but two patients were treated with anticoagulant therapy.

In conclusion, early filter thrombosis appears to be due to intracaval extension of deep vein thrombosis, and this emphasizes the need for appropriate anticoagulation. In the case of temporary contraindication to anticoagulation at the time of the filter placement, anticoagulant should be reassessed later.

Eur Respir J., 1996, 9, 2012–2016.

Depts of *Intensive Care, **Internal Medicine, +Cardiology, and ++Radiology, Hopital Bellevue, Saint-Etienne, France

Correspondence: B. Tardy
Service d'Urgences Médicales
Hopital Bellevue
Bd Pasteur
CHRU
Saint-Etienne 42055
France

Keywords: Filter
pulmonary embolism
thrombolysis
vena cava
venous thrombosis

Received: March 19 1996
Accepted after revision June 30 1996

This study has been presented at the XVth Congress of the International Society on Thrombosis and Haemostasis, Jerusalem, Israel, June 11–16, 1995.

Inferior vena cava (IVC) filters have been available for over 20 yrs. Major complications of permanent IVC filters include insertion site deep vein thrombosis (DVT), migration of the filter, erosion of the filter through the IVC wall, recurrent pulmonary embolism despite filter placement, IVC obstruction, and lower extremity venous insufficiency [1]. IVC filter thrombosis is a particular complication which, to our knowledge, has never been studied in large series. Therefore, the period of occurrence, the possible influence of anticoagulation, the clinical manifestations, the diagnosis and the treatment of the filter thrombosis are not well-known. We present 30 cases of such a complication observed over an 8 year period.

Material and methods

The clinical and radiological findings of patients with a previous vena cava filter, who were consecutively admitted to our department between January 1987 and December 1994 for a clinical suspicion of IVC filter thrombosis, were retrospectively reviewed. All percutaneous types of IVC filter were considered but IVC thrombosis in patients with vena cava clip or ligature were excluded. Patients with previous IVC thrombosis before filter placement were also excluded. To be included in this study, the diagnosis of IVC filter thrombosis had to be assessed by venacavography and/or dynamic computed tomographic (CT) scanning and/or duplex ultrasonography, and the thrombus had to have extended into the filter. To be considered, deep vein thrombosis and pulmonary embolism had to be established, respectively, by venacavography, duplex ultrasonography and high probability ventilation/perfusion scan or pulmonary angiography.

The following filters were used: Amplatz and Bird's Nest filters (Cook, Bloomington, USA); Anthéor filter (Anthéor, Loudun, France); Greenfield filter (Medi-tech, Watertown, USA); Günther filter (Cook Europe, Bjaverskov, Denmark); LGM filter (L.G. Medical, Chasseneuil, France); and Simon-Nitinol filter (Nitinol Medical Technologies, Worburn, USA).

Results

Over an 8 year period, vena cava filter thrombosis was demonstrated in 30 patients in our institution. There were 19 males (63%) and 11 females (37%) aged 44–87 yrs (mean 74 yrs) (tables 1 and 2). All patients had a deep vein thrombosis extending to the popliteal, femoral or iliac vein when the filter was placed. Indications for filter placement were: a contraindication to anticoagulation in eight patients (27%); recurrent emboli despite adequate anticoagulation in three patients (10%); and

Table 1. – Details of the patients with early filter thrombosis

Pt No.	Age yrs	Sex	Filter Indication	Filter Type	Associated treatment after filter placement, and duration	Delay of thrombosis following filter placement	Clinical presentation	Results of V/P scan or angiogram	Level of thrombus from the top of filter
1	60	F	CI	LGM	-	1 month	DVT	A+	Under
2	72	M	P	LGM	OA 1 month	1 month	Bilateral oedema + lumbar pain	ND	Under
3	75	F	RE	LGM	OA 10 days	10 days	DVT	S-	Above 2 cm
4	85	F	P	LGM	-	4 months	DVT	S-	Under
5	78	M	RE	LGM	OA 2 months	2 months	DVT	S-	Under
6	70	M	P	Pietri	-	2 months	DVT + PE	ND	Under
7	69	F	CI	LGM	-	4 months	DVT	S-	Under
8	82	M	CI	LGM	-	4 months	Bilateral oedema	S+	Above 2 cm
9	76	F	RE	LGM	-	15 days	Collateral abdominal circulation	ND	Under
10	73	M	CI	Gunther	-	10 days	DVT	ND	Under
11	44	M	CI	LGM	-	3 months	DVT	ND	Under
12	67	M	CI	LGM	-	1 month	DVT	S-	Above 2 cm
13	83	M	P	LGM	UH 2 months	2 months	Collateral abdominal circulation	S-	Under
14	95	F	P	LGM	UH 2 days	2 days	Bilateral oedema	ND	Under
15	76	F	P	Antheor	OA 3 months	5 months	DVT + PE	A+	Under

Pt: patient; F: female; M: male; CI: contraindication to anticoagulant therapy; P: prophylactic; RE: recurrent embolism; UH: unfractionated heparin; OA: oral anticoagulant; DVT: deep vein thrombosis; PE: pulmonary embolism; ND: not done; S: ventilation/perfusion scan; A: angiography; V/P: ventilation/perfusion; -: negative; +: positive.

Table 2. – Details of the patients with late filter thrombosis

Pt No.	Age yrs	Sex	Filter Indication	Filter Type	Associated treatment after filter placement, and duration	Delay of thrombosis following filter placement	Clinical presentation	Results of V/P scan or angiogram	Level of thrombus from the top of filter
16	82	M	P	Mobin	-	60 months	DVT	ND	Under
17	82	F	P	LGM	OA 3 months	15 months	DVT	S+	Under
18	67	M	P	Gunther	OA 20 months	24 months	DVT + PE	A+	Above 4 cm
19	58	M	P	Greenfield	OA 6 months	84 months	Bilateral oedema + lumbar pain	S-	Above 4 cm
20	77	F	P	Gunther	-	60 months	DVT	S-	Above 2 cm
21	70	M	P	Greenfield	-	72 months	PE	S+	Under
22	68	M	P	Greenfield	-	24 months	DVT	S-	Under
23	87	M	P	Greenfield	OA 36 months	84 months	Lumbar pain	S-	Above 2 cm
24	85	M	CI	LGM	-	7 months	Collateral abdominal circulation	S+	Under
25	79	M	P	Greenfield	OA 18 months	24 months	DVT	S-	Under
26	65	M	P	Gunther	OA 6 months	13 months	DVT	S+	Above 4 cm
27	61	M	P	LGM	OA 3 months	12 months	Bilateral oedema + lumbar pain	S-	Above 2 cm
28	83	M	CI	Greenfield	-	13 months	PE	S+, A+	Under
29	78	F	P	Antheor	OA 17 months	18 months	PE	A+	Above 4 cm
30	70	F	P	Gunther	OA 12 monthhs	84 months	DVT	S-	Under

For definitions see legend to table 1.

prophylaxis for pulmonary embolism in 19 patients (63%). Details of contraindication to anticoagulation and of prophylactic indications are presented in table 3.

At the time of filter placement, no patient had known protein C, protein S or antithrombin III deficiency; two patients had been treated for prostatic cancer (cases Nos. 5 and 10), and one patient for breast carcinoma (case No. 9). Six different types of filter were encountered: LGM in 15 patients; Stainless steel Greenfield in six patients, Gunther in five; Antheor in two; and Mobin-Uddin and Pietri in one patient each. The filters were placed *via* the right internal jugular vein in 14 patients (Greenfield 6; LGM 3; Gunther 3; Mobin-Uddin: 1; Pietri 1) and *via* a femoral vein in 16 patients (LGM 12; Antheor 2, Gunther 2). After filter placement, anticoagulation therapy was initiated in 15 cases for 10 days to 36 months, and was subsequently stopped in 10 cases (in case No. 23 because of the occurrence of a haemorrhagic tamponade) (tables 1 and 2).

In the group of patients as a whole, the mean delay between the diagnosis of filter occlusion and its placement was 20.8 months (2 days to 84 months). However, in 15 patients (50%), filter thrombosis occurred during the first 6 months after filter placement (table 1). Among these 15 patients (early filter thrombosis group), 10 received no anticoagulant treatment at the time of diagnosis of filter thrombosis. Moreover, none of the other five patients was in the therapeutic range for anticoagulation

Table 3. – Indications for filter placement in 27 patients

Contraindication to heparin (n=8)	Pt No.	Prophylaxis (n=19)	Pt No.
Intracerebral haemorrhage	1, 11, 24	Chronic pulmonary insufficiency	16, 26, 27, 30
Haemopericarditis during heparin therapy	7	History of DVT and/or PE	2, 4, 13, 14, 17, 18, 20, 21, 23, 25
Gastric haemorrhage during heparin therapy	8, 10, 12, 28	Current massive PE	6, 15, 19, 29
		Hemiplagia	22

For cases Nos. 3, 5 and 9, the indication was a recurrent pulmonary embolism despite heparin therapy. Pt: patient; DVT: deep vein thrombosis; PE: pulmonary embolism.

at the time of diagnosis of filter thrombosis (two with an activated partial thromboplastin time (APTT) less than 1.5 times the normal control, and three with an international normalized ratio (IRN) <1.5). Among the 15 patients with late occlusion of filter (table 2), none were treated with oral anticoagulant at the time of diagnosis. In this group, the mean delay of occurrence of filter occlusion was 39.1 months for patients who had been treated for at least 6 months with oral anticoagulant, compared with 39.3 months for patients who had never been treated. In the early filter thrombosis group, it is remarkable to note that the occlusion was associated with an LGM filter in 12 of the 15 cases (80%), whilst in the later thrombosis group, occlusion was observed with all types of filter.

In 18 out of 30 cases (60%), the occlusion of the filter was revealed by symptoms of recurrent DVT (tables 1 and 2). Among these 18 patients, the recurrent thrombosis was located on the same side as the first episode of thrombosis in 14 cases, and was controlateral in four cases. Other symptoms were pulmonary embolism alone in three cases, acute bilateral oedema and/or acute lumbar pain in six cases, and recent collateral abdominal circulation in three cases (tables 1 and 2). Among a total of six patients with symptomatic pulmonary embolism, a vascular obstruction of more than 55% was found in two patients (cases Nos. 15 and 18). A new malignancy was found in two patients, hepatic metastases (case No. 3) and gastric adenocarcinoma (case No. 6). No death occurred during the acute phase of filter thrombosis, but patient No. 3 died 4 months later; no autopsy was performed.

Following duplex ultrasonography, which was practised in all but six cases (Nos. 10, 16 and 27–30), filter occlusion was suspected in all cases, but to establish the diagnosis a venacavography was necessary in 16 cases, and a CT scan in five. The IVC filter thrombosis was extended to the common iliac vein in three cases (Nos. 17, 19 and 21) and was associated with a popliteal-femoral-iliac thrombosis in the 27 other cases. A thrombus extending at least 2 cm above the filter was found in 10 cases (33%) (tables 1 and 2). In five cases (Nos. 18, 20, 23, 24 and 26) the filter occlusion was associated with a caudal migration of the filter, which spread into the iliac vein in two cases (Nos. 18 and 26). These filter migrations were all associated with a late filter thrombosis. Of the five Gunther filter thromboses of this series, three were associated with caudal migration. Pulmonary angiography and/or ventilation/perfusion scan were performed in 23 cases and showed a pulmonary embolism and/or high probability perfusion defects in 10 patients (33%), six of whom were symptomatic.

Heparin treatment was instituted in 28 cases (with nonfractionated heparin in 25 cases and with low molecular weight heparin in three, cases Nos. 9, 12 and 14). No treatment was administered because of high haemorrhagic risk in two cases (Nos. 24 and 28). Peripheral intravenous thrombolytic therapy with low-dose urokinase (2,000 $U \cdot kg^{-1} \cdot h^{-1}$) for 12 h) was administered in seven cases (Nos. 8, 15, 19, 20, 22, 26 and 29); and a complete lysis of the filter thrombus was observed in only two cases (Nos. 20 and 29). Of the eight patients with absolute contraindication for anticoagulation at the time of filter placement, six (cases Nos. 1, 7, 8 and 10–12) were treated with heparin 10 days to 4 months later, and one of these (case No. 8) also received thrombolytic treatment 4 months later. A temporary Amplatz filter was placed before the thrombolytic treatment in case No. 26, and a second Antheor filter was placed after the failure of thrombolytic therapy in case No. 15. In one case, in which the filter had moved caudally into the left iliac vein, a second filter was placed in the IVC (case No. 18). Oral anticoagulation was then instituted for at least 3 months in all except the two patients with high haemorrhagic risk and the three patients treated with low molecular weight heparin. In eight cases, a duplex sonography was performed 3–6 months later (cases Nos. 2, 3, 15, 18, 20–22 and 29), and a complete or partial lysis of the filter thrombus was observed in five cases.

Discussion

To our knowledge, there have been few data published relating to the incidence, the mechanisms, the clinical presentation and the management of IVC filter thrombosis.

Because no systematic patient follow-up was performed in the present study and since asymptomatic filter thrombosis might exist, the overall incidence of filter thrombosis cannot be estimated from these results. Unfortunately, as most previous studies of caval patency after filter placement had unsystematic investigations or short follow-up, the real frequency of filter thrombosis is only approximate. Following placement of Greenfield, LGM, Simon nitinol, Amplatz, and Bird's Nest filters, the rate of IVC thrombosis has been reported as 6.2% (5 out of 81 patients), 7.8% (7 out of 90), 16.7% (3 out of 18), 17.5% (7 out of 40), 18.9% (7 out of 39), respectively [1–5]. In a study evaluating caval patency after placement of LGM and Gunther filters using venacavography and/or rheoplethysmography, early (first 8 days) and late (mean 5.7±5.4 months) filter occlusions were found in 3.4% (3 out of 87 filters) and 10.3% (9 out of 87 filters), respectively [6]. Among 35 patients with LGM filters, with a mean follow-up of 12.2 weeks, a clot was demonstrated in 13 filters (37%) on cavograms, CT scan,

intravascular ultrasonographic (US) scans, or autopsy [7]. The thrombus was occlusive in four patients, extending 2–13 cm above the filter in seven patients (20%) [7]. Among 34 patients with Amplatz filters, evaluated 1 month later by venacavography, four (11.8%) presented filter occlusion, three of whom had a clot extending above the filter [2]. Finally, all these studies tend to confirm that IVC filter thrombosis is not a rare event, the frequency of which is probably underestimated.

There are several potential causes of filter thrombosis. As was suspected with the Mobin-Uddin umbrella (60% of IVC thrombosis), which was withdrawn from the market in 1986 [8, 9], this complication is probably related, in part, to the thrombogenic potential of each device. In the present study, even though the LGM filter is the most frequently used in our hospital (189 among 338 filter placements in 8 yrs) it is very strange to note that 80% of early filter thrombosis occurred with this device. This observation is consistent with a recent study on LGM filters showing, with a mean follow-up of 2 months, that 22% of patients (14 out of 64) had proven IVC thrombosis [10]. Filter thrombosis may also be related to thrombus-trapping by the device. Efficient thrombus-trapping by a filter may, indeed, lead to a high rate of IVC thrombosis. A third possible cause of filter thrombosis is the intracaval extension of a proximal DVT. In the present study, this mechanism probably preponderates, as all but three patients had a popliteal-femoral-iliac DVT when filter thrombosis was diagnosed.

These points raise the question of the administration of anticoagulant therapy in the absence of contraindication. To our knowledge, the possible efficacy of concomitant anticoagulation to prevent IVC thrombosis has never been prospectively studied. In a nonconsecutive series of Greenfield filter placements, in which all patients had a contraindication to anticoagulation therapy, IVC obstruction occurred in nine (15.3%) of the 59 patients examined [11]. In two of the newer design filter series, the IVC obstruction rate was 7.8% (9 out of 116), despite continued anticoagulation for all patients [4, 12]. In the present study, 83% of patients (25 out of 30) had no oral anticoagulant therapy at the time of diagnosis of filter thrombosis and, especially in the early thrombosis group, there were no patients with either anticoagulant therapy or appropriate dose of anticoagulant. This may indicate, as some authors have suggested [1, 13], that in the case of proximal DVT, concomitant anticoagulation after filter placement is desirable when there are no contraindications, in order to prevent early IVC and filter thrombosis.

In the case of absolute but transient contraindication to anticoagulant at the time of filter placement, the need for institution of anticoagulant therapy should be reassessed later, and the use of temporary filters could be a better alternative [14]. In the case of late filter thrombosis, the delay between filter placement and the occurrence of filter thrombosis was similar between patients who had never been treated with anticoagulant (39.3 months) and patients who have received such therapy for at least 6 months (39.1 months). Others have found no correlation between long-term anticoagulation and filter patency [15, 16]. Hence, in the absence of contraindication, whether or not anticoagulant therapy is necessary for the long-term patency of filters remains an open question, and probably depends on the risk of recurrence of DVT and the reduction of flow in the IVC, depending on the type of filter [17].

In most case reports found in the literature, pulmonary embolism, fatal or not, seems the most common complication to IVC filter thrombosis [18–21]. In the present study, pulmonary embolism was found in 33% of patients but was clinically suspected in only 20%. In contrast, signs or symptoms compatible with recurrent DVT were present in 60% of cases, and DVT was found by objective investigations in 90% (27 out of 30 patients). Therefore, in our experience, the occurrence of contralateral or recurrent DVT or lower limb swelling should lead to prompt evaluation of caval patency. Whilst recurrent pulmonary embolism is considered an uncommon event following insertion of Greenfield filters (2.4%) [13], this study reports a high incidence of pulmonary embolism in patients with IVC filter thrombosis. The rate of 33% is similar to that observed in a study of 18 patients with caval thrombosis before heparin treatment [22].

In the case of filter thrombosis, pulmonary embolism can occur either through collateral pathways or by means of propagation of caval clots through the filter, as was observed in 10 patients in the present study. It is paradoxical to note that in this study 6 out of 19 patients with a pure prophylactic indication for filter placement, such as chronic pulmonary insufficiency, presented some months later with a new pulmonary embolism. As in the present study with 63% of patients with a pure prophylactic indication for filter placement, some clinicians have argued for a wider use of filters in extended indications. In fact, 140 filters per million inhabitants are inserted annually in the United States, whereas in Sweden, the number is three [23]. Without a clear demonstration of filter efficacy in pure prophylactic indication, is the risk of major complications, such as filter thrombosis, acceptable?

The diagnosis of IVC filter thrombosis is based on radiological investigations. As has already been suggested [5, 24], duplex ultrasonography alone was unable, in our experience, to demonstrate IVC occlusion in most patients. Moreover, duplex ultrasonography can be technically inadequate in some patients and its reliability to detect thrombi in filters has never been demonstrated. Therefore, in contrast to other reports [15, 25], we believe that invasive radiographic procedures, such as cavography or CT scan, should be performed in all patients with suspicion of IVC thrombosis or recurrent pulmonary embolism after caval filter placement.

The treatment of IVC filter thrombosis is difficult. In the case of IVC thrombosis associated with caudal migration of the filter, as was observed in two patients in the present study, a second filter may eventually be placed if contraindication to anticoagulation persists. Successful treatment with thrombolytic therapy was observed in only two out of seven patients. In these patients, the development of collateral channels was not found on cavograms [26]. This may indicate that the filter thrombosis was recent, and we believe that in such situations thrombolytic therapy should be initiated. In other cases, heparin treatment followed by oral anticoagulation seems the logical treatment in the absence of contraindications.

Despite the large number of publications on experience with IVC filters, in the absence of controlled trials, many questions remain concerning their indication, safety and effectiveness [27]. IVC thrombosis appears to be one of the more frequent and major complications of filter placement. The intracaval extension of proximal DVT is probably the main cause of early thrombosis. However, the thrombogenic potential is probably different for each device and prospective studies, comparing the caval patency in accordance with different filters, are necessary. We also believe that all patients with acute lumbar pain, new or worsened lower limb swelling, signs or symptoms compatible with recurrent DVT and pulmonary embolism should have prompt evaluation of caval patency. Thrombolytic drugs, at least low dose, appear to have little effect in the treatment of IVC thrombosis, except in the absence of development of caval collateral channels which may indicate acute thrombosis. When anticoagulation is contraindicated in patients with venous thrombosis or when it fails to prevent pulmonary embolism, the need for mechanical protection is generally accepted [28]. In contrast, since there is no consensus about criteria for prophylactic caval interruption [29], and the frequency of thrombosed filters is not insignificant, with a 33% rate of pulmonary embolism, inferior vena cava filters for prophylactic indication should be used with caution and controlled clinical trials are recommended.

References

1. Becker DM, Philbrick JT, Selby JB. Inferior vena cava filters: indications, safety, effectiveness. *Arch Intern Med* 1992; 152: 1985–1994.
2. Epstein DH, Darcy MD. Hunter DW, Coleman CC, Tadavarthy SM, Murray PD. Experience with the Amplatz retrievable vena cava filter. *Radiology* 1989; 172: 105–110.
3. Roehm JOF, Johnsrude IS, Barth MH, Gianturco C. The Bird's nest inferior vena cava filter: progress report. *Radiology* 1988; 168: 745–749.
4. Ricco JB, Crochet D, Sebillotte P, *et al.* Percutaneous tranvenous caval interruption with the LGM filter: early results of a multicenter trial. *Ann Vasc Surg* 1988; 3: 242–247.
5. Kim D, Edelman RR, Margolin CJ, *et al.* The Simon nitinol filter: evaluation by MR and ultrasound. *Angiology* 1992; 43: 541–548.
6. Babuty D, Quilliet L, Charbonnier B, Lang M, Mycinsky C, Desveaux B. Interruption of inferior vena cava with percutaneous filter. *Arch Mal Coeur* 1990; 83: 1389–1396.
7. Murphy TP, Dorfman GS, Yedlicka JW, *et al.* LGM vena cava filter: objective evaluation of early results. *JVIR* 1991; 2: 107–115.
8. Cimochowsi GE, Evans RH, Zatins CK, Lu CT, DeMeester TR. Greenfield *versus* Mobin-Uddin umbrella: the continuing quest for the ideal method of vena caval interruption. *J Thorac Cardiovasc Surg* 1980; 79: 358–365.
9. Mobbin-Uddin K, Utley JR, Bryant LR. The inferior vena cava umbrella filter. *Prog Cardiovasc Dis* 1975; 17: 391–399.
10. Millward SF, Marsh JI, Peterson RA, *et al*. LGM (Vena Tech) vena cava filter: clinical experience in 64 patients. *JVIR* 1991; 2: 429–433.
11. Kolachalam RB, Julian TB. Clinical presentation of thrombosed Greenfield filters. *Vasc Surg* 1990; 9: 666–670.
12. Castellani L, Nicaise H, Pietri J, Quilliet L, Desvaux B, Alison D. Transvenous interruption of the inferior vena cava. *Int Angiol* 1987; 6: 299–306.
13. Kanter B, Moser KM. The vena cava filter. *Chest* 1988; 93: 170–175.
14. Kunisch M, Rauber K, Bachmann G, Rau WS. Temporary cava filter: effective prophylaxis of pulmonary embolism in venous thrombosis in the region of pelvic vacular system and of the vena cava inferior? *Fortschr Röntgenstr* 1995; 163: 523–526.
15. Crochet DP, Stora O, Ferry D, *et al.* Vena Tech LGM filter: long-term results of a prospective study. *Radiology* 1993; 188: 857–860.
16. Jones B, Fink JA, Donovan DL, Sharp WV. Analysis of benefit of anticoagulation after placement of Kimray-Greenfield filter. *Surg Gynecol Obstet* 1989; 169: 400–402.
17. Katsamouris AA, Waltman AC, Delichatsios MA, Athanasoulis CA. Inferior vena cava filters: *in vitro* comparison of clot-trapping and flow dynamics. *Radiology* 1988; 166: 361–366.
18. Cull DL, Wheeler JR, Gregory RT, Snyder SO, Gayle RG, Parent FN. The Vena Tech filter: evaluation of a new inferior vena cava interruption device. *J Cardiovasc Surg* 1991; 32: 691–696.
19. Carabasi RA, Moritz MJ, Jarrell BE. Complications encountered with the use of Greenfield filter. *Am J Surg* 1987; 154: 163–168.
20. Magnant JG, Walsh DB, Juravky LI, Cronenwett JL. Current use of inferior vena cava filters. *J Vasc Surg* 1992; 16: 701–706.
21. Hye RJ, Mitchell AT, Dory CE, Freischlag JA, Roberts AC. Analysis of the transition to percutaneous placement of Greenfield filters. *Arch Surg* 1990; 125: 1550–1553.
22. Girard P, Hauuy MP, Musset D, Simonneau G, Petitpretz P. Acute inferior vena thrombosis: early results of heparin therapy. *Chest* 1989; 95: 284–291.
23. Bergqvist D. The role of vena cava interruption in patients with venous thromboembolism. *Prog Cardiovasc Dis* 1994; 1: 25–37.
24. Gugliemo FF, Kurtz AB, Wechsler RJ. Prospective comparison of computed tomography and duplex sonography in the evaluation of recently inserted Kimray-Greenfield filters into the inferior vena cava. *Clin Imaging* 1990; 14: 216–220.
25. Pasto ME, Kurtz AB, Jarrell BE, *et al.* The Kimray-Greenfield filter: evaluation by duplex real time/pulsed doppler ultrasound. *Radiology* 1983; 148: 223–226.
26. Tardy B, Page Y, Zeni F, Lafond P, Decousus H, Bertrand JC. Acute thrombosis of a vena cava filter with a clot above the filter: successful treatment with low-dose urokinase. *Chest* 1994; 106: 1607–1609.
27. Dorfman GS. Evaluating the roles and function of vena caval filters: will data be available before or after these devices are removed from the market? *Radiology* 1992; 185: 15–17.
28. Neuerburg J, Günther RW. Developments in inferior vena filters: a European viewpoint. *Semin Intervent Radiol* 1994; 2: 349–357.
29. Page Y, Decousus H, Tardy B, *et al.* Criteria for prophylactic caval interruption in venous thromboembolism: a survey (Abstract). *Am Rev Respir Dis* 1993; 4: A1001.