Radiology

Inferior Vena Cava Thrombosis Risk in 1582 Patients with Inferior Vena Cava Filters

Nicholas Xiao, MD • Jennifer Karp, RN • Robert Lewandowski, MD • Michael Cuttica, MD • Daniel Schimmel, MD • Karlyn Martin, MD • Kush R. Desai, MD

From the Departments of Radiology, Division of Interventional Radiology (N.X., J.K., R.L., K.R.D.), and Medicine, Divisions of Pulmonary and Critical Care (M.C.), Cardiology (D.S.), and Hematology/Oncology (K.M.), Northwestern University, 676 N St. Clair St, Suite 800, Chicago, IL 60611. Received May 7, 2021; revision requested June 18; revision received November 9; accepted November 18. **Address correspondence to** K.R.D. (e-mail: *kdesai007@northwestern.edu*).

Conflicts of interest are listed at the end of this article.

Radiology 2022; 303:300–302 • https://doi.org/10.1148/radiol.211169 • Content code: CA

An indwelling inferior vena cava (IVC) filter (IVCF) may predispose one to IVC thrombosis (IVCT), which can result in substantial patient morbidity. Historically high use of IVCF has left a large population at risk for IVCT; however, there are limited data informing its prevalence and potential predisposing risk factors, which are essential for limiting complications in patients with an IVCF (1,2).

We aim to evaluate the incidence of IVCT among patients with an IVCF and identify risk factors that are associated with the development of IVCT.

Materials and Methods

An institutional review board–approved and Health Insurance Portability and Accountability Act–compliant retrospective review of all patients with an IVCF between January 1, 2009, and January 1, 2019, who underwent either catheter venography (at the time of retrieval) or CT imaging of the abdomen or pelvis was included in this study. Informed consent was waived by the institutional review board. Patients were routinely observed in a dedicated IVCF clinic where imaging and retrieval were performed, as clinically indicated. Patients who underwent no follow-up imaging after filter placement were excluded from the study. IVCT was defined as complete caval thrombosis through the indwelling filter. History of prior venous thromboembolism (VTE), neurologic disease, prior or current malignancy, known genetic hypercoagulability, contraindications to anticoagulation, anticoagulation therapy at the time of follow-up, IVCF model, and implantation time were assessed for association with IVCT. Filter types used in fewer than 50 patients were excluded from statistical analysis. Neurologic disease included any disorder involving the brain or spine, including neurologic cancers or injuries. Sensitivity analysis and logistic regression were performed at implantation times of 6, 12, and 24 months to assess for temporal association with IVCT.

Univariable analysis was performed to evaluate for association of IVCT with potential risk factors. A Bonferroni correction was applied, and $P < .0026$ (ie, .05/19) indicated a significant difference. To assess for independent predictors, multivariable logistic regression models using Firth penalized likelihood were constructed using the significant risk factors identified in the univariable analysis. Results were expressed as odds ratios (ORs), with 95% CIs.

Results

A total of 2077 patients were encountered over the study period, and 1582 met inclusion criteria (Table 1). IVCF-related IVCT occurred in 38 patients (2%), all of whom were symptomatic with varying degrees of postthrombotic syndrome. Male sex (OR, 5.0), central neurologic disease (OR, 4.4), and implantation time longer than 6 (OR, 3.8) or 12 (OR, 3.1) months were deemed significant at univariable analysis (Table 2). These variables remained significant with multivariate adjustment.

Mean filter implantation time was 17 months. Mean time from filter placement to diagnosis of IVCT was 33 months. Seventeen filter types were encountered in this study; Denali filters (OR, 8.9) were significantly associated with IVCT (Table 2).

Discussion

Filter-related inferior vena cava (IVC) thrombosis (IVCT) can result in debilitating symptoms secondary to postthrombotic syndrome (2,3). The reported incidence of filter-related IVCT in the literature is highly variable, ranging from 1.6% to 33%, which is poorly informative of the true risk of IVC filter (IVCF)-related thrombosis (1,2). These prior studies are also outdated, as most were conducted in an era of low re-

Table 1: Patient Characteristics and Occurrence of IVCT

Characteristic	Finding
No. of patients	1582
Sex	
Male	828 (52)
Female	754 (48)
Age (y)*	56.5 ±16.2
Follow-up imaging modality	
Contrast-enhanced CT	298 (19)
Catheter venography	1522 (96)
No. of IVCTs	38 (2)
Implantation time (mo)†	2.5 (17 ± 69.4)
Time to IVCT diagnosis (mo)*	32.9 ± 56.5

Note.—Unless otherwise indicated, data in parentheses are percentages. IVCT = inferior vena cava thrombosis.
* Data are mean ± standard deviation.
† Data are the median, with mean ± standard deviation in parentheses.

trieval rates, poor follow-up, and with fewer filter types. In this cohort reflective of current practice patterns, IVCT was seen in 2% of cases and was significantly higher in male patients, those with neurologic disease, and Denali filters. These results are consistent with prior studies suggesting a predilection for proximal venous thromboembolism (VTE) in men (3,4). While the mechanism by which neurologic derangements are associated with VTE remains unclear, studies have shown that hypercoagulability can result from prothrombotic factors released from damaged nervous tissue, with compounding risk for VTE related to stasis from impaired mobility (4,5).

Patients with filter dwell times longer than 6 months showed significantly higher rates of inferior vena cava (IVC) thrombosis (IVCT), suggesting that those with long-dwelling IVC filter (IVCF) have increased risk of developing IVCT. Most patients in this cohort underwent prompt retrieval of their IVCFs before 6 months of implantation, skewing toward lower overall dwell times and potentially underestimating risk of IVCF-related IVCT. Other limitations of this study include its retrospective nature and nonuniformity of imaging follow-up. However, the data presented accurately reflect clinical practice and provide guidance in assessing risk of IVCF-related IVCT.

Table 2: Association of Risk Factors and Occurrence of IVCF-related IVCT

Comorbidity	No. of Patients	No. of IVCTs	Univariable OR	*P* Value*	Multivariable OR†	*P* Value
Male sex	828 (52)	32 (3.8)	5.0 [2.1, 12.1]	<.001‡	4.3 [1.8, 10.4]	.001‡
History of VTE	1051 (66)	25 (2.4)	0.9 [0.5, 1.9]	.923	…	…
Contraindication to anticoagulation	1367 (85)	32 (2.3)	0.8 [0.3, 2.0]	.635	…	…
Anticoagulation at follow-up	1069 (72)	30 (2.8)	2.3 [0.9, 6.0]	.084	…	…
Central neurologic disease	390 (25)	22 (5.6)	4.4 [2.3, 8.5]	<.001‡	3.8 [2.0, 7.5]	.001‡
Hypercoagulability						
Protein C or S deficiency	7 (0.4)	1 (14)	6.9 [0.8, 60.0]	.053	…	…
Antiphospholipid syndrome	19 (1)	0 (0)	1.1 [0.06, 17.1]	.991	…	…
Factor V Leiden	36 (2)	1 (2.8)	1.2 [0.2, 8.7]	.882	…	…
Prothrombin mutation	2 (0.1)	0 (0)	8.0 [0.4, 169.7]	.182	…	…
History of malignancy	408 (26)	7 (1.7)	0.6 [2.8, 1.5]	.297	…	…
Implantation time (mo)§						
>6	365 (23)	19 (5.2)	3.8 [2.0, 7.2]	<.001‡	4.0 [1.9, 8.5]	<.001‡
>12	224 (14)	13 (5.8)	3.1 [1.5, 6.1]	.001‡	3.7 [1.8, 7.5]	<.001‡
>24	185 (12)	9 (4.9)	2.3 [1.1, 4.9]	.034	…	…
Filter type						
ALN (ALN Implants Chirugircaux)	445 (28)	5 (1.1)	1 [Reference]	…	…	…
Denali (Bard Peripheral Vascular)	50 (3)	5 (10.0)	8.9 [2.5, 31.8]	.001‡	6.1 [1.6, 23.3]	.008‡
Celect (Cook Medical)	529 (33)	11 (2.1)	1.9 [0.7, 5.5]	.243	…	…
G2 (Bard Peripheral Vascular)	50 (3)	1 (2.0)	1.7 [0.2, 15.5]	.602	…	…
Option (Argon Medical Devices)	125 (8)	2 (1.6)	0.82 [0.1, 7.1]	.90	…	…
Gunther Tulip (Cook Medical)	218 (14)	8 (3.7)	3.3 [1.1, 10.1]	.040	…	…
Other (Trapease [Cordis], Recovery [Bard], Venatech Convertible [B. Braun], Simon Nitinol [Bard], Greenfield [Boston Scientific], Optease [Cordis], VenaTech [B. Braum], Crux [Volcano], Eclipse [Bard])	165 (10)	6 (3.6)	…	…	…	…

Note.—Data in parentheses are percentages, and data in brackets are 95% CIs. IVCF = inferior vena cava filter, IVCT = inferior vena cava thrombosis, OR = odds ratio, VTE = venous thromboembolism.

* Significance for univariable analysis was accepted at $P < .0026$ (0.05/19) after Bonferroni correction.

† Multivariable logistic regression models using Firth penalized likelihood were constructed using the significant risk factors identified in the univariable analysis.

‡ Difference is significant.

§ Multivariable analysis of implantation time was performed with each respective time category separately with male sex, central neurologic disease, and Denali filters.

Acknowledgment: The authors acknowledge and thank statistical analyst Nicola Lancki, MPH, for her assistance and oversight of the statistical methods used in this study.

Author contributions: Guarantors of integrity of entire study, **N.X., M.C., K.R.D.**; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; approval of final version of submitted manuscript, all authors; agrees to ensure any questions related to the work are appropriately resolved, all authors; literature research, **N.X., K.R.D.**; clinical studies, **N.X., J.K., R.L., K.M., K.R.D.**; statistical analysis, **N.X., J.K., K.R.D.**; and manuscript editing, **N.X., R.L., M.C., D.S., K.M., K.R.D.**

Disclosures of conflicts of interest: **N.X.** no relevant relationships. **J.K.** no relevant relationships. **R.L.** consulting fees and payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing, or educational events from Boston Scientific. **M.C.** grants from Bayer Actelion; consulting fees from United Therapeutics and Bayer Actelion; payment for speakers bureaus from United Therapeutics and Bayer Actelion. **D.S.** no relevant relationships. **K.M.** funding from Janssen Scientific Affairs for investigator-initiated study. **K.R.D.** speakers bureau and consulting fees from Cook Medical, Becton Dickinson, Boston Scientific, Medtronic, and Penumbra; consulting fees from W.L. Gore, Philips, Cordis, and Tactile Medical; deputy editor for RSNA Case Collection.

References

1. PREPIC Study Group. Eight-year follow-up of patients with permanent vena cava filters in the prevention of pulmonary embolism: the PREPIC (Prevention du Risque d'Embolie Pulmonaire par Interruption Cave) randomized study. Circulation 2005;112(3):416–422.
2. Alkhouli M, Morad M, Narins CR, Raza F, Bashir R. Inferior Vena Cava Thrombosis. JACC Cardiovasc Interv 2016;9(7):629–643.
3. Agnelli G, Verso M, Ageno W, et al. The MASTER registry on venous thromboembolism: description of the study cohort. Thromb Res 2008;121(5):605–610.
4. Trinchero A, Scheres LJJ, Prochaska JH, et al. Sex-specific differences in the distal versus proximal presenting location of acute deep vein thrombosis. Thromb Res 2018;172:74–79.
5. Samuels JM, Moore EE, Silliman CC, et al. Severe traumatic brain injury is associated with a unique coagulopathy phenotype. J Trauma Acute Care Surg 2019;86(4):686–693.