ORIGINAL INVESTIGATION

Twenty-one-Year Trends in the Use of Inferior Vena Cava Filters

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Background: Improved inferior vena cava (IVC) filters have led to liberalization of the indications for insertion. Increased use, however, has been followed with a potential for unwarranted insertion. There are only sparse data on trends in the use of IVC filters in patients with pulmonary embolism (PE), patients with deep venous thrombosis (DVT) alone, and patients at high risk. We analyzed the National Hospital Discharge Survey (NHDS) database for such trends.

Methods: We used data from the NHDS, which is based on a national probability sample of discharges from short-stay nonfederal hospitals in 50 states and the District of Columbia. The numbers of sampled patients with DVT, PE, and IVC filters were determined from the *International Classification of Diseases, Ninth Revision, Clinical Modification* codes at discharge.

Results: The number of patients who had IVC filters increased from 2000 in 1979 to 49 000 in 1999. In 1999, 45% of IVC filter insertions were in patients with DVT alone, 36% were in patients with PE, and 19% were in patients who presumably were at high risk but did not have DVT or PE listed as a discharge code. The use of IVC filters was more frequent in northeastern states than in western states ($P = .01$).

Conclusions: The use of IVC filters increased markedly during the last 2 decades in patients with PE, patients with DVT alone, and patients at risk who had neither PE nor DVT. Randomized controlled trials may lead to improved risk stratification and limit the number of unnecessary filter insertions.

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IMPROVED TECHNOLOGY IN THE FABrication of inferior vena cava (IVC) filters has made them less thrombogenic, smaller, easier to insert percutaneously, safer, and in some instances retrievable[1-4] and capable of insertion at the bedside.[5,6] This has led to a broadening of the indications for insertion.[2,7] The generally accepted indications for IVC filter insertion are patients in whom recurrent pulmonary embolism (PE) occurred despite adequate treatment with anticoagulants or in whom anticoagulant therapy is contraindicated.[7,8] Additional indications include patients with chronic recurrent PE and pulmonary hypertension and patients undergoing embolectomy or thromboendarterectomy.[8] Broader indications (patients with poor cardiopulmonary reserve in whom even a small recurrent PE might be fatal and patients who show a free-floating thrombus in the IVC) now account for 46% to 65% of IVC filter insertions.[2] More liberal recommendations by some include prophylaxis in patients with cancer,[9] trauma,[10,11] burns,[12] or acetabular fracture[13]; hip or knee replacement in patients with a history of thromboembolism[14]; or prophylaxis in all patients with deep venous thrombosis (DVT) or PE, especially if the patient is older than 65 years.[15]

With more liberal indications, increased use of IVC filters has followed,[3,7,16] with a potential for unwarranted insertion.[7] To our knowledge, there is a lack of data on relative safety and efficacy.[17] Proper selection of patients for IVC filter insertion is an important challenge.[10] The nonselective use of IVC filters is associated with unacceptable morbidity and mortality.[7] Some estimate that only a few patients among those surveyed would have benefited from an IVC filter.[18] They recommend, therefore, that use of filters be restricted until benefit has been confirmed by prospective studies.[18]

An analysis of records of Medicare patients indicates that the use of IVC filters is increasing in elderly patients.[16] There are no other reports for the United States on trends in the use of IVC filters. In view of the sparse national literature, we analyzed the National Hospital Discharge Survey (NHDS) database[19] for trends over 21 years in the use of IVC filters in patients

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Table 1. *International Classification of Diseases, Ninth Revision, Clinical Modification* Codes for Identification of Patients With Pulmonary Embolism and Deep Venous Thrombosis

Code	Description
For pulmonary embolism	
415.1	Pulmonary embolism and infarction
634.6	Spontaneous abortion complicated by embolism
635.6	Legally induced abortion complicated by embolism
636.6	Illegally induced abortion complicated by embolism
637.6	Unspecified abortion complicated by embolism
638.6	Failed attempted abortion complicated by embolism
673.2	Obstetrical blood-clot embolism
For deep venous thrombosis	
451.1	Phlebitis and thrombophlebitis of deep vessels of lower extremities
451.2	Phlebitis and thrombophlebitis of lower extremities, unspecified
451.8	Phlebitis and thrombophlebitis of other sites
451.9	Phlebitis and thrombophlebitis of unspecified site
453.2	Other venous embolism and thrombosis of vena cava
453.8	Other venous embolism and thrombosis of other specified veins
453.9	Other venous embolism and thrombosis of unspecified site
671.3	Deep phlebothrombosis, antepartum
671.4	Deep phlebothrombosis, postpartum
671.9	Unspecified venous complication in pregnancy and the puerperium

with PE, patients with DVT but not PE, and patients with no diagnosis of DVT or PE who presumably were at high risk.

METHODS

DATA SOURCES

Data from the NHDS were used for this study.[20] Data from this study are available on CD-ROM.[19] The NHDS is based on a national probability sample of discharges from noninstitutional hospitals exclusive of federal, military, and Department of Veterans Affairs hospitals located in the 50 states and the District of Columbia. A 3-stage sampling plan was introduced in 1988 and replaced an earlier, similarly designed 2-stage sampling plan.[20] For both designs, there is a probability sample of hospitals and a systematic sampling procedure to select discharges within hospitals. The changes introduced with the 1988 redesign do not compromise the ability to conduct trend analysis.[20]

First-Stage Sampling: Primary Sampling Units

There were 112 primary sampling units, which are composed of counties, groups of counties, county equivalents (such as parishes or independent cities), or towns and townships.

Second-Stage Sampling: Hospitals

Hospitals in the primary sampling unit that had 1000 or more beds were always selected for inclusion in the survey and termed *certainty hospitals*.[19] All other hospitals were selected using systematic random sampling. These were selected from the primary sampling units with a probability proportional to their annual number of discharges.

Third-Stage Sampling: Discharges

A sample of discharges from each hospital was selected by a systematic random sampling technique.

ESTIMATION PROCEDURES

Estimates of the number of patients with DVT and PE and the number of patients with IVC filters in the United States were derived from the number of sampled patients with DVT, PE, and IVC filters. This was done using a multistage estimation procedure that produces essentially unbiased national estimates and has 3 basic components: inflation by reciprocals of the probabilities of sample selection, adjustment for nonresponding hospitals and missing discharges within hospitals, and population weighting ratio adjustments.[19] Because the statistics from the survey are based on a sample, they may be different from the figures that would have been obtained if a complete census had been taken. The number of responding hospitals and sampled patient abstracts in the survey for 1979 through 1999 ranged from 400 to 494 and 181 000 to 307 000, respectively.[19] The NHDS samples approximately 8% of hospitals and approximately 1% of discharges.

IDENTIFICATION OF VENOUS THROMBOEMBOLISM CASES

Since 1979, the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*)[21] has been used for classifying diagnoses and procedures in the NHDS. The *ICD-9-CM* codes that we used for identification of patients with PE and DVT are given in **Table 1.** The *ICD-9-CM* code used for insertion of an IVC filter was 38.7: "Interruption of the vena cava, insertion of implant or sieve in vena cava, ligation of vena cava (inferior, superior), plication of vena cava." From 1979 to 1985, the use of surgical caval interruption decreased to virtually zero.[22] In 1994, the use of vena caval clips was "considered by most to belong to the history of medicine."[23] Before 1999, only 11 cases were reported of filters in the superior vena cava.[24] From 1979 to 1999, therefore, most *ICD-9-CM* codes of 38.7 indicated insertion of a filter in the IVC.

CALCULATION OF IVC FILTER INSERTION RATES AS A PERCENTAGE OF PATIENTS WITH PE OR DVT

Rates of insertion of IVC filters as a percentage of patients with PE or DVT were calculated as follows. The numerator (number of IVC filters inserted during a given period) was obtained from the NHDS. The denominator (number of patients with PE or number with DVT in the absence of PE) was also obtained from the NHDS. The ratio was expressed as a percentage of patients with PE or DVT. The number of patients with DVT only was obtained by subtracting the number of patients with DVT who also had PE from the total number with DVT. The number of patients who had IVC filters inserted prophylactically was calculated as the total number of patients with IVC filters minus the number with IVC filters who had PE or DVT.

Rates of use of filters in western, midwestern, southern, and northeastern regions of the United States were calculated. The states included in the various regions, as defined in the NHDS, are given in **Table 2**. Triennial rates were calculated by dividing the sum of the number of patients who had IVC filters during a 3-year period by the sum of the number of patients with PE or DVT during that 3-year period and multiplying by 100 to obtain the rate in terms of IVC filters per 100 patients with DVT or PE.

STATISTICAL ANALYSIS AND METHODOLOGIC CONSIDERATIONS

Trends in relative numbers of patients with IVC filters and the use of IVC filters will be the focus of this article, because hospital discharge data may incompletely capture all IVC filter insertions and all diagnoses of DVT and PE. Linear regression analyses (InStat version 3.0; GraphPad Software, San Diego, Calif) were used to calculate the slopes of linear segments describing the data.[25] Pearson product moment correlation analyses were used to assess the extent of dispersion of points around the regression lines. Differences between groups and differences in the rates of use of IVC filters over time were assessed using unpaired *t* tests when 2 groups were compared and analysis of variance when multiple groups were compared.[25] Differences of rates were assessed by χ^2 analysis.

RESULTS

The number of IVC filters inserted yearly during the 21-year period of observation increased from 2000 in 1979 to 49 000 in 1999. The number inserted yearly began to increase sharply in 1988. In 1999, 22 000 IVC filters were in hospitalized patients with DVT, 18 000 in patients with PE, and 9000 in patients who did not have a coded diagnosis of DVT or PE (**Figure 1**). In 1999, 45% of IVC filter insertions were in patients with DVT alone, 36% were in patients with PE, and 19% were in patients who presumably were at high risk but did not have DVT or PE listed as a discharge code.

The percentage of patients with PE who had IVC filters inserted increased from 0.7% in the triennial period 1979-1981 to 12% in 1997-1999 (**Table 3** and **Figure 2**). The percentage of patients with DVT who had IVC filters inserted increased from 0.2% in 1979-1981 to 6% in 1997-1999 (Figure 2). The percentage of patients with PE who had IVC filters inserted increased linearly during the 21-year period of observation (slope = 2.03 IVC filters per 100 patients with PE yearly, $r = 0.980$, $P < .001$) as did the percentage of patients with DVT who had IVC filters (slope = 1.09, $r = 0.978$, $P < .001$) (Figure 2). The rate ratio of use of IVC filters in patients with PE to those with DVT during 1997-1999 was 1.86 (95% confidence interval, 1.84-1.88; $P < .001$).

During the 21-year period of observation, the percentage of patients in whom IVC filters were inserted, for both PE and DVT, was comparable in men and women, black and white patients, and elderly (≥70 years) and younger patients (20-69 years). Regional differences in the use of IVC filters for patients with PE and/or DVT are shown in **Figure 3**. The use of IVC filters during the 21-year period of observation was more frequent in northeastern states than in western states ($P = .01$) (Figure 3).

COMMENT

These data show a prominent trend toward increased use of IVC filters during the past 2 decades. The number of IVC filters inserted was higher in patients with DVT than in those with PE, reflecting the higher number of patients with DVT. However, the percentage of patients with PE who had IVC filters exceeded the per-

Table 2. Regions of the United States Defined According to States*

West	Midwest	South	Northeast
Alaska	Illinois	Delaware	Maine
Arizona	Indiana	Maryland	New Hampshire
California	Iowa	District of Columbia	Vermont
Colorado	Kansas	Virginia	Massachusetts
Hawaii	Michigan	West Virginia	Connecticut
Idaho	Minnesota	North Carolina	Rhode Island
Montana	Missouri	South Carolina	New York
Nevada	Nebraska	Georgia	New Jersey
New Mexico	North Dakota	Florida	Pennsylvania
Oregon	Ohio	Kentucky	
Utah	South Dakota	Tennessee	
Washington	Wisconsin	Alabama	
Wyoming		Mississippi	
		Arkansas	
		Louisiana	
		Oklahoma	
		Texas	

*From the National Hospital Discharge Survey Multi-year Data File 1979-1999.[19]

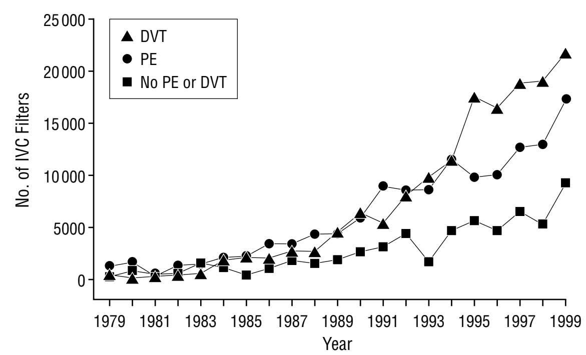

Figure 1. Number of inferior vena cava (IVC) filters inserted between 1979 and 1999 in patients with pulmonary embolism (PE), deep venous thrombosis (DVT) alone, and neither PE nor DVT.

Table 3. Patients With PE and DVT Who Had IVC Filter Insertion

	No. (%) With IVC Filters	
Year	**PE Patients**	**DVT Patients**
1979-1981	3000/429 000 (0.7)	1000/662 000 (0.2)
1982-1984	5000/390 000 (1.3)	3000/724 000 (0.4)
1985-1987	9000/360 000 (2.5)	7000/690 000 (1.0)
1988-1990	15 000/300 000 (5.0)	14 000/635 000 (2.2)
1991-1993	26 000/293 000 (8.9)	24 000/692 000 (3.5)
1994-1996	31 000/313 000 (9.9)	46 000/875 000 (5.3)
1997-1999	44 000/372 000 (11.8)	60 000/946 000 (6.3)
Total	133 000/**2 457 000** (5.4)	155 000/**5 225 000** (3.0)

Abbreviations: DVT, deep venous thrombosis; IVC, inferior vena cava; PE, pulmonary embolism.

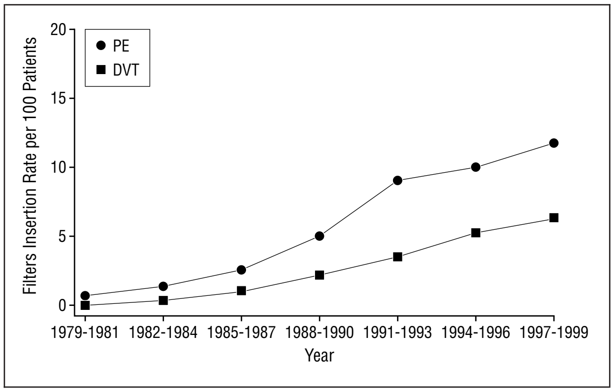

Figure 2. Rates of insertion of inferior vena cava (IVC) filters per 100 patients with pulmonary embolism (PE) and rates of insertion per 100 patients with deep venous thrombosis (DVT) alone.

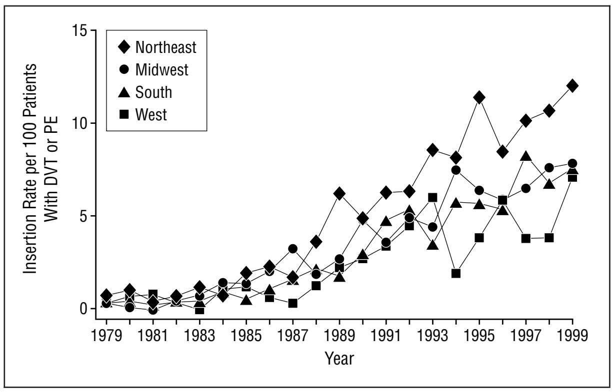

Figure 3. Rates of insertion of inferior vena cava (IVC) filters per 100 patients with deep venous thrombosis (DVT) and/or pulmonary embolism (PE) according to region in the United States. The states in each region are given in Table 2.

centage of patients with DVT. In 1999, use of IVC filters in patients at high risk who had neither PE nor DVT constituted 19% of IVC filter insertions. Trends comparable to the national trends that we observed have previously been shown in a study of the experience of a university hospital.[22]

Although the use of IVC filters is increasing, many of the indications for insertion of IVC filters are a matter of opinion.[26] Some observed that the prophylactic use of IVC filters in patients following trauma failed to decrease the overall rate of PE.[27] Others observed that the use of an IVC filter in patients with DVT or PE did not decrease the rate of rehospitalization for recurrent DVT or PE compared with patients treated with anticoagulants alone.[28] There is a paucity of studies that compare the use of IVC filters with anticoagulant therapy.[17,29]

Our analysis of the data from the NHDS show regional differences in the rate of use of IVC filters, the highest being in the northeastern states and the lowest in the western states, giving further evidence of differences of opinion regarding the indications for IVC filter use. Regional differences in the use of IVC filters in Medicare patients, with greater use in the New England states than on the Pacific coast,[16] previously have been shown. Differences in the rate of IVC filter insertion between the United States and Sweden[23] suggest differences of opinion across national borders.

There is uniform agreement[30] that an IVC filter should be inserted in a patient with proximal DVT or PE if (1) anticoagulants are contraindicated, (2) PE has recurred while receiving adequate anticoagulant therapy, or (3) PE is so severe that any recurrent PE may be fatal. Insertion of an IVC filter is also recommended in patients following pulmonary embolectomy.[8] It is believed that routine insertion of an IVC filter is not indicated only on the basis of a continuing predisposition for DVT.[30] In special circumstances, however, this may be the best approach. Some have recommended prophylactic insertion of IVC filters for high-risk patients with DVT, severe pulmonary hypertension, and minimal cardiopulmonary reserve.[31]

A variety of IVC filters have been designed for percutaneous insertion.[32-38] They differ in outer diameter of the delivery system, maximal caval diameter into which they can be inserted, hook design, retrievability, biocompatibility, and filtering efficiency.

On average, 29% of patients with IVC filters suffer complications.[7] Complications from IVC filter insertion include improper anatomic placement of the filter (7%), migration (2%-3%), angulation of the filter (2%), caval stenosis or filter narrowing (2%), caval occlusion (2%-9%), air embolism (1%), penetration of the caval wall (1%), lower extremity edema (13%-26%), and sequelae of venous stasis (27%).[7,10,39,40] Deep venous thrombosis at the puncture site, reviewed by Greenfield, has been reported in a few to 41%.[41] Additional complications include filter deformation, filter fracture, insufficient opening of the filter, and erosion of the caval wall.[40] Among patients with percutaneous steel Greenfield filters, 2.6% had a new PE on follow-up.[42] In a review of investigations since 1994 of trauma patients who had a filter inserted prophylactically, 1.5% had a PE.[10]

The NHDS is based on a methodologically rigorous sample of diagnoses of DVT and PE and use of IVC filters in the entire diverse population of the United States. The size of the NHDS database and its broad representation make it well suited to assess trends in the use of IVC filters in the United States during 2 recent decades.

Trends shown in this analysis are stronger than absolute numbers because of a possible lack of sensitivity of coding of discharge records.[43] However, clinically significant procedures, such as insertion of an IVC filter, are likely to be coded with a 90% sensitivity.[43] The number of IVC filters inserted would be at least the number identified by the NHDS. Between 1979 and 1985, some of the coded procedures may have been open surgical ligation, plication, or insertion of an IVC filter.[22] After 1985, virtually all of the coded vena cava procedures were transvenous insertion of an IVC filter.[22] Only a few case reports of insertion of a filter in the superior vena cava were reported before 1999.[24,44,45] The number of IVC filters identified by our analysis of the NHDS database corresponds closely to the estimate of 30 000 to 40 000 IVC filters inserted yearly, based on calculations by industry.[46]

In conclusion, our analysis of the NHDS database shows a prominent increase in use of IVC filters during the past 2 decades, with a striking increase in prophylactic use. The data further show a prominent difference in use of filters according to the region of the country. Recognizing that the nonselective use of IVC filters may lead to an unacceptable morbidity and mortality,[7] these trends in use of IVC filters identify an urgent need for randomized controlled studies to improve risk stratification and limit the number of unnecessary filter insertions.

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