

Persistently low inferior vena cava filter retrieval rates in a population-based cohort



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ABSTRACT

Background: Practice patterns associated with inferior vena cava (IVC) filter placement have seen considerable variation in the last decade. We used a statewide administrative database to examine trends in IVC filter placement and retrieval in the general population.

Methods: We reviewed Florida state inpatient and ambulatory surgery databases from 2004 to 2014. *International Classification of Diseases, Ninth Revision* diagnosis and procedure codes and *Current Procedural Terminology* codes were searched for patients undergoing inpatient or outpatient IVC filter placement, and each patient was longitudinally tracked to the time of inpatient or outpatient filter retrieval. For inpatient filter placements, associated diagnoses were reviewed to identify indications for placement. Univariate and multivariate logistic regression models were constructed to identify factors associated with improved retrieval rates.

Results: During the 11-year period, 131,791 IVC filter placements were identified, with a 50% increase from 2004 to 2010 and a 24% decline from 2010 to 2014. Median age at filter placement was 71 years (interquartile range, 57-81 years). Mean follow-up after filter placement was 17.3 ± 25.5 months. Only 8637 filters (6.6%) were retrieved. The annual retrieval rate trended upward, from 3.4% in 2004 to 8.5% in 2013 ($P < .001$). Median filter dwell time was 96.5 days (interquartile range, 44-178 days). Diagnoses associated with filter placement included venous thromboembolism (75.9%), trauma (35.0%), hemorrhage (29.9%), malignant disease (29.4%), and stroke (5.1%). Retrieval rates were highest in younger patients (34.0% in patients younger than 20 years) and lowest in Medicare patients (2.5%). In a multivariate logistic regression model, Medicare was associated with decreased retrieval rates (odds ratio, 0.33; 95% confidence interval, 0.31-0.35; $P < .001$) after adjusting for age and associated diagnoses. Weaker risk factors included increased age, white race, and diagnoses of deep venous thrombosis, pulmonary embolism, and malignant disease. A trauma diagnosis was associated with improved retrieval. To further investigate the Medicare effect, a propensity score-matched model was created to better account for confounding effects. In this model, Medicare persisted as a risk factor for decreased filter retrieval (odds ratio, 0.43; 95% confidence interval, 0.40-0.46; $P < .001$).

Conclusions: IVC filter placements, after a substantial increase between 2004 and 2010, have been declining since 2010. Retrieval rates in the general population are steadily improving but continue to lag behind those described in center-specific literature. Increased age and Medicare as the primary payer are the strongest risk factors for lack of filter retrieval. Widespread improvements on a national scale are needed to improve the appropriateness of filter placements and to enhance filter retrieval rates. (*J Vasc Surg: Venous and Lym Dis* 2019;7:38-44.)

Keywords: Inferior vena cava filter; Retrieval; Venous thromboembolism; Deep venous thrombosis; Pulmonary embolism

Inferior vena cava (IVC) interruption provides an alternative treatment modality to anticoagulation in patients with deep venous thrombosis (DVT) or pulmonary embolism (PE) for prevention of future PE events and has gained significant popularity during the past few decades. Since development of the original Greenfield filter in 1973, the use of IVC filters has expanded greatly, driven by improvements in delivery systems allowing percutaneous placement, clinical data justifying their

use,¹ and initial approval by the U.S. Food and Drug Administration (FDA) in 2003 for labeling of certain filters as retrievable.² The 2012 guidelines written by the American College of Chest Physicians strongly recommended the use of IVC filters in patients with acute DVT or PE who have a contraindication to or are unable to tolerate therapeutic anticoagulation.³ Further recommendations in 2016 specifically advised against the use of IVC filters in patients who could be treated with

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anticoagulants.⁴ However, prophylactic indications, although controversial, have significantly contributed to the rise in IVC filter placements in the United States.⁵ Increasing volume of filter placement may also be related to more widespread concern regarding PE prevention or increased use of IVC filters by specialties outside of vascular surgery and interventional radiology.

In recent years, there has been increasing scrutiny both within and outside the medical community on the appropriateness of IVC filter placement and retrieval. Rising awareness of the complications associated with indwelling filters led to widespread interest in improving retrieval rates. In 2010, the FDA, after reviewing reports to their Manufacturer and User Facility Device Experience (MAUDE) database, issued a communication advising that “implanting physicians and clinicians responsible for the ongoing care of patients with retrievable IVC filters consider removing the filter as soon as possible when protection from PE is no longer needed”⁶; this warning was reiterated in 2014.⁷ In 2012, the Centers for Medicare and Medicaid Services (CMS) introduced changes to the coding for IVC filters, bundling the procedural and radiologic codes for filter placement (consequently reducing average reimbursement) and creating a new code for filter retrieval. Malpractice suits involving the placement and retrieval of filters have become more common in the past two decades, with both proceduralists themselves and their referring providers being commonly named in lawsuits. Referring providers are most commonly sued for failure to recommend filter placement, whereas proceduralists are most commonly sued for issues surrounding filter-related complications.⁸

Many centers have made significant improvements in their filter retrieval rates by changing their protocols to better capture patients with retrievable filters who meet indications for retrieval. These interventions include creation of a filter registry to track patients, scheduling of follow-up visits after filter placement to discuss retrieval, and education of physicians in appropriate indications for placement and retrieval of IVC filters.⁹⁻¹⁵ Single-center retrieval rates range widely but are commonly reported in the 30% to 60% range.^{9-11,13-16} In addition, a meta-analysis of 37 prospective filter trials found a mean retrieval rate of 34%.¹⁷

However, despite the abundance of single-center data, true retrieval rates in the general population are not well described. In one study from 2011,¹⁸ Medicare claims data from 1999 to 2008 were reviewed for filter placement and retrieval procedures. During this time, there was a 112% increase in annual volume of filter placements, with an estimated retrieval rate of 1.2% to 5.1% in 2008. This study suggests that the true retrieval rates in the general population may be significantly lower than those reported from individual centers. Our objective was to use a statewide population-based administrative database to capture IVC filter placements and retrievals in a

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective review of a state-wide administrative database
- **Take Home Message:** Between 2004 and 2014, there were 131,791 inferior vena cava filters placed in Florida, with a 50% increase from 2004 to 2010 and a 24% decrease from 2010 to 2014; only 8637 (6.6%) were retrieved. Rates of retrieval increased over time from 3.4% in 2004 to 8.5% in 2013 ($P < .001$), with higher retrieval rates in younger patients (34% in patients aged <20 years) and the lowest retrieval rates in Medicare patients (2.5%).
- **Recommendation:** The study confirms that actions on a national scale are needed to improve appropriateness of inferior vena cava filter placement and retrieval rates.

real-world setting to estimate the true population-wide retrieval rate and to identify the factors that predict retrieval rates in the general population.

METHODS

As this study used a deidentified administrative data source, Institutional Review Board approval and informed consent were not required. We used the 2004 to 2014 data from the Florida state inpatient database (which includes all inpatient hospital stays) and the state ambulatory surgery database (which includes all outpatient procedures) available from the Healthcare Cost and Utilization Project in partnership with the Agency for Healthcare Research and Quality. Together, these two databases contain records from every inpatient hospital encounter and every outpatient procedure within Florida state during an 11-year period. Patients are longitudinally linked within and across both databases by a deidentified patient number that can be used to track a patient across multiple hospital visits and procedures. Florida state data were specifically chosen for this study as one of the few states with linkage at the patient level across the entire 11-year period studied.¹⁹ Admission and secondary diagnoses for each hospitalization are classified by *International Classification of Diseases, Ninth Revision* (ICD-9) diagnosis codes. Procedures are classified in inpatient records by ICD-9 procedure codes and in outpatient records by *Current Procedural Terminology* (CPT) codes. In 2012, CMS introduced new changes to CPT coding of filter-related procedures, including the bundling of procedural and radiologic codes for filter placement and creation of a new code for filter retrieval. These coding changes were reflected in our search strategy.

We queried the database to identify all patients who had an IVC filter placed, on either an inpatient or outpatient basis, between 2004 and 2014. Inpatient filter

placements were identified by the ICD-9 procedure code for IVC interruption (38.7), and outpatient filter placements were identified by CPT codes for IVC filter placement (37620 from 2004-2011 and 37191 from 2012-2014). Demographic and comorbidity data were collected for each patient. For inpatient placements, both the primary/admission diagnosis and secondary diagnosis codes were reviewed to identify patients with diagnoses of acute or chronic DVT or PE. Other diagnoses possibly related to the indication for filter placement, including trauma, hemorrhage, malignant disease, stroke, and obesity, were also noted.

After creation of a list of IVC filter placements, each patient was longitudinally observed through future inpatient and outpatient encounters to determine whether the filter was retrieved. Before 2012, there was no ICD-9 or CPT procedure code specifically indicating filter retrieval. Thus, a filter was considered to be retrieved if the same patient underwent a subsequent procedure on a different day with any of a number of codes that may be associated with filter retrieval. This was done through an algorithm that queried the database for all possible filter retrievals, which were then matched to the list of filter placements to identify the filters that were retrieved. In the inpatient database, the ICD-9 codes for angiography of the vena cava (88.51), other endovascular procedure (39.79), or other vessel operation (39.99) were used. In the outpatient database, the CPT code for transcatheter foreign body retrieval (37203) was used before 2012 and the new code for IVC filter retrieval (37193) was used from 2012 to 2014. In both cases, these procedures were marked as retrievals only if they were performed within 1 year of filter placement as they were believed to be less specific for retrieval of the index filter at later time points.

Stata 14.2 (StataCorp LP, College Station, Tex) was used for all statistical analyses. Standard descriptive statistics were used to summarize baseline characteristics. Retrieval rates were calculated for the entire population and specific subgroups of interest and compared by χ^2 test. Trends over time in placement and retrieval rates were demonstrated graphically by annual volume and evaluated by χ^2 tests. Finally, logistic regression modeling was used to identify factors associated with higher or lower retrieval rates. Baseline characteristics and diagnoses for filter placement were used as candidate predictors, and a multivariate model was constructed using a backward-stepwise elimination selection process to identify independent predictors of poorer retrieval rates.

RESULTS

In 28,700,034 hospital encounters and 32,464,275 outpatient procedures from 2004 to 2014 in Florida state, a total of 131,791 IVC filters were placed. Baseline characteristics are summarized in [Table I](#). The median age at the time of filter placement was 71 years (interquartile

Table I. Baseline characteristics of all patients with filters placed

Characteristic	Median (IQR) or %
Age, years	71 (57-81)
Female	50.9
White	70.4
Hypertension	57.5
Diabetes mellitus	26.1
Coronary artery disease	24.3
Congestive heart failure	16.5
Chronic obstructive pulmonary disease	19.9
Chronic kidney disease	13.1
Cerebrovascular disease	9.8
Bleeding disorder	16.9
Medicare as primary payer	63.8
<i>IQR</i> , Interquartile range.	

range, 57-81 years). Only 6.5% of filters were placed in the outpatient setting, with the majority being placed during an inpatient admission. Diagnoses associated with inpatient filter placement are summarized in [Table II](#). There was an admission diagnosis of either DVT or PE in 33.3% of patients; 75.9% of patients had either an admission or a secondary diagnosis of DVT or PE, suggesting that 24.1% of filters were placed for a prophylactic indication. There was a 50% increase in the annual volume of filter placements from 2004 to 2010 with a subsequent 24% decline from 2010 to 2014 ([Fig 1](#)). The downward trajectory did not appear to change in 2012 when the coding changes were introduced.

The mean follow-up after filter placement was 17.3 ± 25.5 months. A total of 8637 filters were retrieved, for an overall retrieval rate of 6.6%. The median filter dwell time before retrieval was 96.5 days (interquartile range,

Table II. Diagnoses attached to inpatient encounters in which filters were placed

Diagnosis	%
VTE (as admitting diagnosis)	33.3
DVT	19.0
PE	14.4
VTE (as any diagnosis)	75.9
DVT	62.1
PE	34.0
Malignant disease	29.4
Trauma	34.9
Acute stroke	5.1
Hemorrhage	29.9
Obesity	11.5
<i>DVT</i> , Deep venous thrombosis; <i>PE</i> , pulmonary embolism; <i>VTE</i> , venous thromboembolism.	

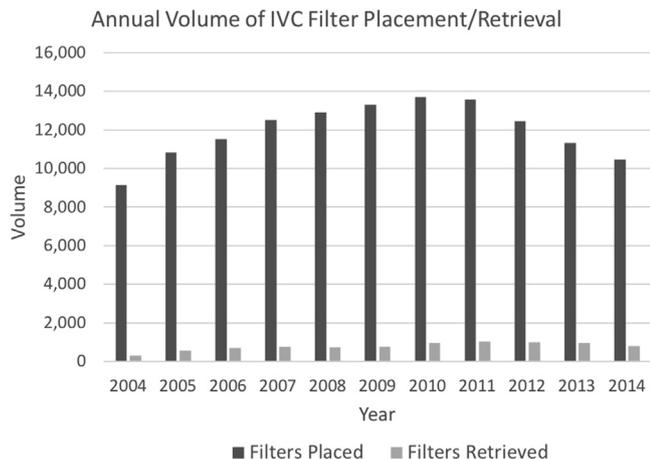


Fig 1. Annual volume of placements and retrievals of inferior vena cava (IVC) filters in Florida state from 2004 to 2014.

44-178 days); 49.9% of the retrievals were performed in the outpatient setting. The volume of retrievals and annual retrieval rate increased steadily over time from 3.4% in 2004 to a peak of 8.5% in 2013 ($P < .001$; Figs 1 and 2). As with filter placements, the trajectory of the increase in retrieval rates did not appear to change in 2012.

A number of univariate risk factors were found to be associated with lower retrieval rates (Table III; odds ratio [OR] <1 indicates lower retrieval rate). Age was strongly associated with retrieval; the retrieval rate was 34.0% in patients younger than 20 years compared with 1.9% in patients aged 80 years or older ($P < .001$). There was a stepwise decrease in retrieval rate with increasing age (OR, 0.63 per decade; 95% confidence interval [CI], 0.62-0.64; $P < .001$). The other notable univariate predictor was Medicare as the primary payer (OR, 0.164; 95% CI, 0.156-0.172; $P < .001$). The retrieval rate in Medicare patients was 2.5% compared with 13.7% in those with other payers ($P < .001$). Less significant univariate

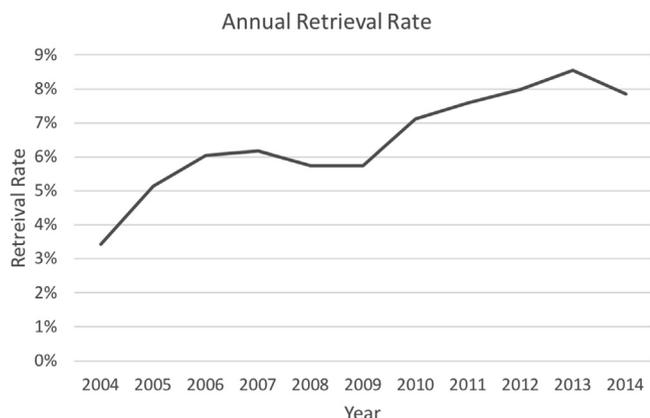


Fig 2. Annual inferior vena cava (IVC) filter retrieval rate.

Table III. Significant univariate predictors of filter retrieval

Predictor	Univariate		
	OR	95% CI	P value
Trauma	2.07	1.99-2.17	$<.001$
Hemorrhage	1.16	1.10-1.21	$<.001$
Stroke	1.10	1.0002-1.21	.050
Female	0.76	0.72-0.79	$<.001$
Admission diagnosis of PE	0.70	0.65-0.75	$<.001$
Age (per decade)	0.63	0.62-0.64	$<.001$
White	0.59	0.56-0.61	$<.001$
Admission diagnosis of DVT	0.50	0.47-0.54	$<.001$
Malignant disease	0.48	0.45-0.51	$<.001$
Obesity	1.06	0.99-1.13	.10
Medicare	0.164	0.156-0.172	$<.001$

CI, Confidence interval; DVT, deep venous thrombosis; OR, odds ratio; PE, pulmonary embolism.
OR <1 indicates lower retrieval rate.

predictors were an admission diagnosis of DVT or PE; any associated diagnosis of malignant disease, trauma, hemorrhage, or obesity; female sex; and white race. A multivariate logistic regression model identified eight independent predictors of retrieval rate (Table IV). Despite adjusting for age and other risk factors, Medicare remained an independent risk factor for poorer retrieval rates (OR, 0.33; 95% CI, 0.31-0.35; $P < .001$). Age also persisted as an independent risk factor (OR, 0.79 per decade; 95% CI, 0.78-0.80; $P < .001$). A trauma diagnosis was associated with improved retrieval rates, whereas diagnoses of DVT, PE, malignant disease, obesity, and white race were associated with lower retrieval rates.

To further evaluate the Medicare effect seen in our multivariate model, an additional exploratory analysis was conducted with the use of a propensity score-matched cohort. Medicare patients were matched to similar non-Medicare patients based on a propensity score derived from demographic and clinical baseline

Table IV. Independent predictors of filter retrieval in a multivariate logistic regression model

Predictor	Multivariate		
	OR	95% CI	P value
Trauma	1.39	1.31-1.46	$<.001$
Admission diagnosis of PE	0.89	0.82-0.96	.003
Obesity	0.86	0.80-0.93	$<.001$
Age (per decade)	0.79	0.78-0.80	$<.001$
Admission diagnosis of DVT	0.76	0.70-0.82	$<.001$
White race	0.69	0.66-0.73	$<.001$
Malignant disease	0.66	0.62-0.70	$<.001$
Medicare	0.33	0.31-0.35	$<.001$

CI, Confidence interval; DVT, deep venous thrombosis; OR, odds ratio; PE, pulmonary embolism.
OR <1 indicates lower retrieval rate.

Table V. Independent predictors of filter retrieval in a multivariate logistic regression model using a cohort of propensity score-matched Medicare and non-Medicare patients

Predictor	Multivariate OR	95% CI	P value
Trauma	1.44	1.36-1.52	<.001
Male	0.93	0.89-0.98	.01
Obesity	0.84	0.77-0.90	<.001
Primary DVT	0.80	0.74-0.87	<.001
Age (per decade)	0.78	0.77-0.80	<.001
White race	0.72	0.69-0.76	<.001
Malignant disease	0.59	0.55-0.64	<.001
Medicare	0.43	0.40-0.46	<.001

CI, Confidence interval; *DVT*, deep venous thrombosis; *OR*, odds ratio. OR <1 indicates lower retrieval rate.

characteristics. Patients were matched in a 1:1 fashion without replacement, with a resulting cohort of 86,222 patients (43,111 Medicare and 43,111 non-Medicare patients). A second multivariate logistic regression model was constructed in this cohort, using generalized estimating equations to account for correlated data within each matched pair. The new multivariate model was similar to that in the nonmatched cohort (Table V); Medicare persisted as a risk factor, albeit with a smaller effect size (OR, 0.43; 95% CI, 0.40-0.46; $P < .001$).

DISCUSSION

IVC filter retrieval rates in the general population are poorly characterized. In this study, we used the Florida state inpatient and ambulatory surgery databases to evaluate real-world trends in filter placement and retrieval rates. We found that filter placements in Florida have declined in recent years while the retrieval rate has improved. Filter retrieval rates are overall significantly lower than those reported in single-center literature, estimated at 6.6% in the overall cohort. Older Medicare patients had the lowest retrieval rates, whereas younger trauma patients were most likely to have a filter retrieved.

The discrepancy between our findings and the 30% to 60% retrieval rates reported in single-center studies calls into question whether the more impressive results at specific institutions truly reflect overall practice patterns in the United States. Our findings corroborate those of a previous study with Medicare data that estimated a 1.2% to 5.1% retrieval rate¹⁸ (Medicare patients in our cohort had a 2.5% retrieval rate) as well as of a large single-center study of trauma patients in which the retrieval rate was found to be 8%²⁰ (trauma patients had a 9.6% retrieval rate in our study). In addition, a recently published study reviewed statewide filter placement and retrieval rates in New York and reported an overall retrieval rate of 3.5% between 2005 and 2014.²¹

Our retrieval rates are notably lower than those reported by Brown et al,²² who used a national private insurance claims database and estimated an overall retrieval rate of 18.4%. The lower age, lower proportion of Medicare patients, and ability to account for mortality as a competing risk all likely contributed to a higher estimate of retrieval rates by these investigators compared with our study; however, despite all these factors, the authors still found a lower retrieval rate than would be expected on the basis of single-center data. Institutions that report their own retrieval rates are, by definition, interested in their retrieval rates and ways in which they can be improved. It is also possible that financial incentives for filter retrieval are responsible for higher retrieval rates in some centers where physician compensation is based on case volume, and such financial incentives could plausibly be related to the lower retrieval rates in Medicare patients. Nevertheless, the publication bias in available single-center literature may paint an overly optimistic picture of retrieval rates in general practice.

The implication of the remarkably low retrieval rates seen in our data is that although some centers excel at achieving high retrieval rates, the majority of centers across the state of Florida (and likely the nation) are less successful in ensuring that filters are retrieved when they are no longer necessary. Improving filter retrieval rates on a population level will require continued efforts to decrease the number of filters that are placed and to increase the retrieval of these filters. IVC filter placements must be limited to established guidelines, and filters for prophylactic indications or in patients already receiving anticoagulation should be placed sparingly.^{3,4} Improved education of referring providers, including hospitalists, emergency department physicians, and other surgical specialties, on true indications for IVC filters may aid in improving the appropriateness of filter placements, as may changes in policy to better enforce such indications. Available single-center literature can inform the methods by which retrieval rates can be improved. These improvements have largely been achieved through improved follow-up of these patients rather than by implementation of more aggressive indications for retrieval. These include self-monitoring of retrieval rates, maintenance of filter registries, follow-up clinic visits for or telephone calls to patients with implanted filters, and better education of both patients and other physicians about the importance of filter retrieval.⁹⁻¹⁵ An additional strategy we have implemented at our institution is to retrieve filters in the same hospital admission as placement if they are no longer medically indicated by the time of discharge; this mitigates concerns related to poor follow-up in certain populations of patients.

Time trends within our data indicate that filter placement rates have been decreasing since 2010 and that retrieval rates are steadily rising. Both of these trends

are encouraging and reflect increasing caution in placing IVC filters and increasing vigilance in retrieving them. We were surprised to find no specific trajectory change in the rate of either placements or retrievals in 2012, when CMS introduced new procedure codes for IVC filter placement and retrieval. The decrease in filter placements started after 2010 and may be temporally related to the FDA warning issued that year. Retrieval rates have steadily increased even as early as 2004, shortly after the labeling of retrievable filters was first introduced; the cause of this is likely to be multifactorial but almost certainly related to growing concerns about the long-term complications of indwelling IVC filters.

From our multivariate logistic regression model for filter retrieval, we found that older age, Medicare as the primary payer, and a malignant disease diagnosis were notable risk factors for decreased retrieval rates, whereas a trauma diagnosis was associated with increased retrieval rates. It is encouraging that younger patients, who face a more significant long-term risk of filter-related complications, have a relatively high retrieval rate; the lower retrieval rates in older patients may partially be explained by a shorter life expectancy. Patients with filters placed in the setting of malignant disease have been shown to be at increased risk of thrombotic events^{23,24} but also seem to be less likely to have their filters retrieved; this is a potential area for improvement. The most surprising finding in our model was the strong negative effect of Medicare. One potential explanation for this Medicare effect is confounding by age and indication for filter placement. However, in a propensity score-matched model that better accounts for these confounding effects, Medicare persisted as a risk factor. Although confounding may explain the lower retrieval rates in Medicare patients, this is certainly a question that warrants further research.

The limitations of this study are inherent to the data source itself. Because administrative data were used, we had limited insight into the true indications for filter placement, relying only on diagnoses associated with the index hospitalization. Similarly, diagnosis and procedure codes in the data set do not provide information as to whether the filter placed was a retrievable or permanent filter or if, at the time of filter placement, there was ever any intent to retrieve the filter at a later date. It is also possible that we overestimated or underestimated the number of retrievals. We devised our search strategy to maximize the capture of filter retrievals, using a liberal set of procedure codes to represent filter retrieval in the setting of a recently placed filter; this may have resulted in the capture of some nonretrieval procedures. One notable example of this would be an attempted but unsuccessful filter retrieval, which would likely be recorded as IVC venography and would be included as a retrieval by our analysis. Conversely, some true retrievals may have been performed under

procedure codes that were not included in our search and would not have been captured. Finally, our data set was limited to a single state. Patients who underwent filter retrieval in another state would be missed. In addition, numerous policy and demographic factors may exist that affect Florida's filter placement and retrieval rates differently from those in the United States as a whole. For example, the "snowbird" phenomenon (many individuals reside in Florida only during the winter months) may have led to underestimation of retrieval rates. Despite these limitations, our results provide a sobering perspective on the overall retrieval rates in a population-based cohort of patients and highlight the need for broad improvements in the retrieval of indwelling filters.

CONCLUSIONS

IVC filter placements in the general population have decreased since 2010. The estimated retrieval rate between 2004 and 2014 was 6.6%, and although it is steadily improving, it continues to lag behind rates described in the literature and points to publication bias in single-center studies. Significant improvements are needed on a national scale to continue to reduce the number of IVC filters that are placed and to enhance filter retrieval rates in patients who no longer have an appropriate indication for an indwelling IVC filter.

AUTHOR CONTRIBUTIONS

Conception and design: AM, NL

Analysis and interpretation: AM, NL, RC, ET

Data collection: AM, NL

Writing the article: AM

Critical revision of the article: NL, RC, ET

Final approval of the article: AM, NL, RC, ET

Statistical analysis: AM

Obtained funding: Not applicable

Overall responsibility: ET

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