HHS Public Access

Author manuscript

Med Care. Author manuscript; available in PMC 2018 January 01.

Published in final edited form as:

Med Care. 2017 January ; 55(1): 31–36. doi:10.1097/MLR.0000000000000599.

Hospital variation and patient characteristics associated with vena cava filter utilization

Joshua D. Brown, PharmD, MS and **Jeffery C. Talbert, PhD**

Institute for Pharmaceutical Outcomes and Policy, Department of Pharmacy Practice and Science, University of Kentucky College of Pharmacy, Lexington, KY, USA

Abstract

Introduction—There is wide variation in the use of vena cava filter (VCFs).

Objectives—This study assessed the hospital and patient characteristics associated with VCF use in deep vein thrombosis (DVT) and pulmonary embolism (PE).

Methods—Inpatient discharge data from all acute care hospitals with DVT/PE during 2008–2014 in Kentucky were used. Hierarchical logistic regression models were used to evaluate the relationships of study variables with VCF use.

Results—During the study period, 81,922 discharges for DVT/PE were observed and 10.5% of these received a VCF. This included 12,083 cases of PE+DVT, 18,571 cases of PE only, and 51,268 cases of DVT only. VCF use among these groups was 22.7%, 6.0%, and 7.8%, respectively. In adjusted analyses, VCF use was associated with increasing age, indicating that those over age 65 were twice as likely to receive a filter compared to the reference (21–25 year-old) group. Significant comorbidities associated with VCF use included cancer, liver disease, cerebrovascular disease, atrial fibrillation, anemia, and concurrent bleeding. Lower extremity, proximal DVTs, and patients receiving thrombolytic therapy or embolectomy, those having surgery, and those who were unstable or had trauma, were also more likely to receive a filter. Among cancer types, brain and metastatic tumors were significantly associated with VCF use. Between-hospital variation after controlling for all covariates was 7.1%.

Conclusion—There was high variation in use of VCFs. Several high-risk subgroups were more likely to use VCFs including older adults and those with cancer and concurrent bleeding.

Keywords

vena cava filters; deep vein thrombosis; pulmonary embolism

Corresponding author: Dr. Joshua Brown, 789 S. Limestone Dr. #292E, Lexington, KY, 40536. Phone: 479-650-8047; Fax: 859-323-0069; josh.brown@uky.edu.

Co-author: Dr. Jeffery Talbert, 789 S. Limestone Dr. #292E, Lexington, KY, 40536. Phone: 859-323-7141; Fax: 859-323-0069; jeff.talbert@uky.edu

Disclosures

J.D.B is the Humana-Pfizer Research Fellow and is provided salary support from Humana Inc. and Pfizer Inc. Neither organization had any input into the conduct of the study or the manuscript. There are no other conflicts of interest to disclose.

Introduction

Increased utilization of vena cava filters (VCFs) for venous thromboembolism (VTE) has correlated with technical improvements in placement of VCFs as well as development of retrievable devices.[1] By 2006, roughly 9% of cases of deep vein thrombosis (DVT) and 12% of pulmonary embolism (PE) received a VCF and has continued to increase into 2012 with an estimated 259,000 VCFs placed in patients in the United States.[2,3] This increase persists despite mixed recommendations and an overall lack of evidence for the use of VCFs.[4–7]

Given the potential for suboptimal use and wide variation between hospitals,[8] it is important to understand hospital- and patient-level factors associated with utilization. Identifying these factors will assist in assessing the quality of care for patients presenting with DVT/PE and can also indicate subpopulations that may be of interest for future research. Thus, this study sought to characterize patients with VTE who received VCFs and to observe the amount of variation between hospitals.

Methods

Data source

State Inpatient Database (SID) data from Kentucky were used **from 2008–2014**. Data include patient demographic variables (age, gender, race, insurance, ZIP codes) and diagnosis and procedure fields. Data are de-identified and do not include unique patient identifiers, so no longitudinal tracking is possible. The University of Kentucky Institutional Review Board approved of the study.

Study variables

The coding algorithms used are presented in the Appendix and are based on previously published coding algorithms.[8–12] **All diagnoses for DVT (451.xx, 453.xx) and PE (415.1x)** were identified for those 21 and older from acute care hospitals. VCF use was identified by ICD-9-CM procedure code 38.7. Discharges from hospitals where no VCFs were placed over the entire 7-year period were excluded to avoid bias due to hospitals lacking the ability to perform the procedure. Variation in VCF use was described by the mean, median, interquartile range (IQR), and coefficient of variation.

Patients were classified as having DVT only, PE only, or having PE+DVT. Comorbidities identified included cancer, chronic obstructive pulmonary disease, cerebrovascular disease (CVD), atrial fibrillation (AFib), liver disease, hypertension, heart failure, hyperlipidemia, myocardial infarction, cellulitis, trauma, diabetes, infection, pneumonia, renal disease, bleeding, anemia, and sepsis/septic shock.[12,13] In addition, thrombolytic therapy and embolectomy/thrombectomy procedures were identified. Unstable patients were identified as those with shock or ventilator use. Invasive surgical procedures were identified using a validated algorithm.[14] Discharge statuses of “deceased” or “transferred” were also recorded. Age was categorized by 5-year intervals, race was categorized white, black, or other, and insurance classified as commercial, Medicaid, Medicare, or other/self-pay. Individual hospitals were classified as being urban or rural, teaching or non-teaching, and categorized into quartiles by hospital bed size.

Statistical analysis

Comparisons were conducted between demographic and clinical characteristics using t-tests and chi-squared tests where appropriate using an *a priori*, two-sided significance level of 0.05. P-values are reported for comparisons between VCF users and non-users. Hierarchical generalized linear modeling was used (henceforth: hierarchical logistic models) for the binary outcome of VCF use.[15] These models included random effects for each hospital and fixed effects for other covariates.[15,16] A cancer-only model was also estimated in the cancer subgroup with additional variables for cancer site (Table 4). Odds ratios (ORs) and their 95% confidence intervals are presented for each variable from the final, full model. The intraclass correlation coefficient (ICC) was calculated for each model, which measures the variation explained by the hospital random effects. The p-value associated with the ICC corresponds to the comparison of between-hospital variance with $p<0.05$ showing significant differences. In addition, c-statistics were calculated as a measure of model discriminatory power between VCF users and non-users. Akaike (AIC) and Bayesian (BIC) information criterion were included to compare across models, which measure the fit of the models while penalizing for added parameters. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

Results

A total of 70 acute care hospitals were included in the state. Eleven hospitals placed no VCFs and were excluded (N=2,435 patients, 2.9% of total discharges). Among the remaining institutions (N=59), VCF use ranged from 0.4% to 15.2%, mean 7.2%, median 7.2%, IQR 4.1% to 10.1%, and coefficient of variation of 0.54.

There were 81,922 VTE-related hospital discharges and 10.5% of patients (N=7,786) received a VCF. The VCF group tended to have an older age distribution, more PE+DVT, cancer, CVD, AFib, anemia, and trauma compared to those without VCFs (Table 1). The VCF group was also more likely to be unstable, have proximal and lower DVTs, have bleeding, and receive thrombolysis.

The random effects only model resulted in an ICC of 12.0% ($p<0.001$) and c-statistic 0.62, showing that there was a significant difference between hospitals, which explained 12% of the overall variance in use (Table 2). The full model had an ICC of 7.1% ($p<0.001$) and c-statistic of 0.81. The cancer only model had an ICC of 3.5% ($p<0.001$) and c-statistic of 0.81.

The results of the full model (Table 3) showed that beginning at 46–50 years of age, the odds of receiving a VCF increased compared to the reference group (21–25 years-old). This trend continued with those over the age 65 being twice as likely to receive a VCF. Compared to patients with DVT only, those with PE only (OR=3.84 [3.46–4.25]) and PE+DVT (OR=2.73 [2.57–2.90]) were much more likely to receive VCFs. Among DVTs, those with lower DVTs were more than six-fold more likely to receive a VCF compared to upper extremity DVTs. Those with bleeding, cancer, liver disease, anemia, and AFib were also more likely to receive VCFs (Table 3).

Among those with cancer (N=13,104), 1,613 (12.3%) used VCFs. The most common cancers were lung (N=3,931, 30.0% of all cancers) and colorectal cancer (N=1,392, 10.6%). Of the twenty-two cancer sites identified, all but five had higher utilization of VCFs than in the average cohort (Table 4). The highest VCF use was in brain tumors (24.4%), cervical (17.0%), stomach and small intestine (16.3%), colorectal (16.2%), and bladder (15.6%) cancers. After controlling for all other variables, brain tumors (OR=2.31 [1.65–3.23]) remained the only significantly associated tumor site with VCF use while leukemia and breast cancers were negatively associated with use.

Discussion

The primary findings suggest that while there is a wide variation in VCF utilization between institutions, most of that variation is controlled for by patient and hospital characteristics. In the final model, very little variation (~7%) in VCF use was attributed to hospitals. Among comorbid conditions considered, our results show strong associations with VCF use and cancer, CVD, AFib, anemia, and concurrent bleeding. This shows that consideration of baseline risk of thromboembolic and bleeding events is considered at the point of care. However, competing guideline statements make it difficult to assess the appropriateness of VCF use in subgroups at a high-risk of VTE, but not necessarily contraindicated to anticoagulation.[4,5,7] In this study, 20% of patients with bleeding received a VCF, a subgroup that is most likely truly contraindicated to coagulation, and were 2.7 times more likely to receive a filter in adjusted analyses. VCF use was also associated with characteristics that indicate severity including unstable patients, surgery, receipt of thrombolysis or embolectomy procedures, and trauma.

The association between cancer and VCF use prompted a more detailed look into individual cancers. Patients with cancer are at an exceedingly high risk of VTE compared to the general population.[17] Further, given the complexity of regimens, multiple drug-drug or drug-disease interactions, and side effects of cancer treatments and many surgical procedures, systemic anticoagulation may be considered infeasible for many cancer patients.[18] However, prior studies have shown that anticoagulants are often used in addition to VCFs.[3,19] In this study, VCF use was highest for brain cancers, **likely** due to the high risk of intracranial bleeding.

The evidence for VCFs for PE/DVT is mixed, making conclusive arguments for use difficult. In the PREPIC[21,22] and PREPIC-2[23] randomized trials, no significant benefits were observed with VCFs with anticoagulation versus anticoagulation alone during short- and long-term follow-up. Observational studies show that VCFs are associated with improvements in short-term outcomes such as in-hospital mortality, 30-day mortality, and a reduction in subsequent PE events among all VTE patients and certain subgroups (trauma, unstable, and elderly).[24–27] Other studies have shown little or no benefit with VCFs, especially with longer follow-up.[9,19,28,29]

Retrievable filters have become widely used in the last decade. Sarosiek *et al.* evaluated the use of retrievable filters and subsequent complications at a single academic center.[3] Their main findings showed there was attempted retrieval in only 10% of VCFs. Of those retrieved, one-quarter were removed during the index hospitalization and the median time-

to-retrieval was observed to be 122 days after placement. Their study further emphasized the lack of follow-up for patients receiving a VCF and a number of serious complications including filter fracture and migration. The authors emphasized the need for follow-up and proper retrieval of devices to avoid complications associated with VCFs. This has been observed in other studies, as well, showing that utilization and retrieval rates as potential quality of care issues and deserve dedicated interventions to ensure quality outcomes for patients.[30–32]

Although our results suggest no institutional deviance in VCF use, there may still exist a general overuse of these devices, which is not definitively supported by current evidence and is further confounded given the lack of consensus in treatment guidelines. There is a great need for additional research in the effectiveness of VCFs in real-world practice, especially for subgroups at highest risk of complications.

Limitations

Due to the nature of the data, temporality of VCF placement and VTE cannot be assessed. It is probable that some patients receive VCF prior to experience a VTE, which is important for patients who may have received VCFs for prophylaxis, most likely subgroups at higher risk of VTE. Data that allow for temporal assessment of VCF placement and VTE will help in understanding the significance of this limitation. Detailed information on medication utilization or the type of VCF placed (retrievable/permanent, manufacturer) is also not possible with discharge data. This is important to distinguish those who would and would not use anticoagulants in place of, or concurrently with, VCFs as these groups may differ in clinical presentation and treatment course. Previous studies have shown that anticoagulants are often used with VCFs, likely proving that use persists without clear contraindications to anticoagulation therapy.[3] A broader definition of DVT was used than what has been used in other studies as well as extending the diagnosis position for VTE disorders beyond only the primary position. This was done to catch more thrombotic disorders where VCFs may be used. Use of these additional codes contributed 14% of the total VTEs with no difference in the prevalence of VCF utilization for these codes compared to more common codes and patient characteristics were similarly distributed.

The data includes no unique patient-identifying variable, it is possible that multiple records for the same individual are included in the analyses. This would be due to multiple hospitalizations over the time period, including patients who transfer from one facility to another. To investigate the impact of transfers, we included an indicator for whether a patient transferred or not, as this may also indicate severity and influence whether a patient receives a VCF from that institution. Likewise, longitudinal tracking of patients is not possible; thus, short or long term outcomes cannot be assessed using SID data. At both a patient-level and institutional-level, transfer status and transfer rate were not significantly associated with VCF utilization. Finally, the data represent the patient population and medical practice within Kentucky and may have limited generalizability to other areas due to differences in comorbid conditions and practices between regions.

Conclusion

In this study of VCF use in Kentucky, we found that much of the between hospital variation is explained by observed hospital and patient characteristics and little variation existed between hospitals after controlling for these factors. More research is needed to assess the effectiveness of VCFs, especially in high-risk subgroups such as cancer, elderly, high bleed risk, and trauma patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Data were collected by the Kentucky Cabinet for Health and Family Services, Office of Health Policy and provided by the University of Kentucky Center for Clinical and Translational Science. The project described was supported by the National Center for Advancing Translational Sciences, National Institutes of Health, through grant number UL1TR000117. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH. Dr. Brown is supported by a research grant from the Hematology/Oncology Pharmacists Associations.

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Med Care. Author manuscript; available in PMC 2018 January 01.

Table 1

Comparison of patient characteristics between vena cava filter users and non-users

Characteristic		No VCF N=74,136		VCF N=7,786		p-value	% receiving VCF
		N	%	N	%		
Age group	21–25	1,309	1.8%	64	0.8%	<0.001	4.7%
	26–30	1,958	2.6%	109	1.4%		5.3%
	31–35	2,416	3.3%	140	1.8%		5.5%
	36–40	3,092	4.2%	205	2.6%		6.2%
	41–45	4,021	5.4%	292	3.8%		6.8%
	46–50	5,225	7.1%	416	5.3%		7.4%
	51–55	6,565	8.9%	605	7.8%		8.4%
	56–60	7,148	9.6%	716	9.2%		9.1%
	61–65	7,801	10.5%	875	11.2%		10.1%
	66–70	7,780	10.5%	963	12.4%		11.0%
	71–75	7,572	10.2%	950	12.2%		11.1%
	76–80	7,188	9.7%	941	12.1%		11.6%
	81+	12,061	16.3%	1,510	19.4%		11.1%
Gender	Female	39,048	52.7%	3,982	51.1%	<0.05	9.3%
	Male	35,088	47.3%	3,804	48.9%		9.8%
Race	White	65,860	88.8%	7,068	90.8%	<0.001	9.7%
	Black	6,746	9.1%	540	6.9%		7.4%
	Other	1,530	2.1%	178	2.3%		10.4%
Insurance	Other/Self-pay	10,187	13.7%	949	12.2%	<0.001	8.5%
	Medicaid	2,930	4.0%	210	2.7%		6.7%
	Medicare	24,275	32.7%	2,603	33.4%		9.7%
	Commercial	36,744	49.6%	4,024	51.7%		9.9%
Clot type	DVT only	47,274	63.8%	3,994	51.3%	<0.001	7.8%
	PE only	17,466	23.6%	1,105	14.2%		6.0%
	PE with DVT	9,396	12.7%	2,687	34.5%		22.2%

Characteristic		No VCF N=74,136		VCF N=7,786		p-value	% receiving VCF
		N	%	N	%		
Comorbidity	Cancer	11,491	15.5%	1,613	20.7%	<0.001	12.3%
	Metastatic cancer	6,087	8.2%	959	12.3%	<0.001	13.6%
	Heart failure	14,069	19.0%	1,470	18.9%	0.853	9.5%
	Liver disease	3,224	4.3%	420	5.4%	<0.001	11.5%
	Renal disease	20,516	27.7%	2,233	28.7%	<0.001	9.8%
	Diabetes	20,656	27.9%	2,111	27.1%	0.178	9.3%
	Stroke	4,893	6.6%	798	10.2%	<0.001	14.0%
	Hypertension	45,317	61.1%	4,954	63.6%	<0.001	9.9%
	Hyperlipidemia	23,826	32.1%	2,603	33.4%	<0.05	9.8%
	Atrial Fibrillation	10,868	14.7%	1,424	18.3%	<0.001	11.6%
	Cellulitis	6,284	8.5%	398	5.1%	<0.001	6.0%
	COPD	23,630	31.9%	2,528	32.5%	0.256	9.7%
	Sepsis/Septic shock	7,821	10.5%	908	11.7%	<0.001	10.4%
	Infection/Pneumonia	25,051	33.8%	2,712	34.8%	<0.05	9.8%
	Anemia	24,874	33.6%	3,538	45.4%	<0.001	12.5%
	Myocardial infarction	6,700	9.0%	793	10.2%	<0.001	10.6%
	Trauma	3,143	4.2%	558	7.2%	<0.001	15.1%
	Thrombolytic therapy	1,571	2.1%	546	7.0%	<0.001	25.8%
	Embolectomy	249	0.3%	68	0.9%	<0.001	21.5%
	Unstable/ventilator	3,455	4.7%	567	7.3%	<0.001	14.1%
	Proximal DVT	12,651	17.1%	2,966	38.1%	<0.001	19.0%
	Lower DVT	31,538	42.5%	5,997	77.0%	<0.001	16.0%
	Bleeding	4,612	6.2%	1,173	15.1%	<0.001	20.3%
	Surgery	14,340	19.3%	2,177	28.0%	<0.001	13.2%
	Deceased	4,200	5.7%	436	5.6%	0.812	9.4%
	Transfer	1,907	2.6%	155	2.0%	<0.001	7.5%
Urban/rural status	Rural	19,096	25.8%	1,692	21.7%	<0.001	8.1%
	Urban	55,040	74.2%	6,094	78.3%		10.0%

Characteristic		No VCF N=74,136		VCF N=7,786		p-value	% receiving VCF
		N	%	N	%		
Teaching status	Non-teaching	36,792	49.6%	3,210	41.2%	<0.001	8.0%
	Teaching	37,344	50.4%	4,576	58.8%		10.9%
Bed size	≤75 beds	2,500	3.4%	99	1.3%	<0.001	3.8%
	76–135 beds	6,216	8.4%	331	4.3%		5.1%
	136–275 beds	18,761	25.3%	1,718	22.1%		8.4%
	≥276 beds	46,659	62.9%	5,638	72.4%		10.8%

Abbreviations: aOR=adjusted odds ratio; CI=confidence interval; VCF=vena cava filter; DVT=deep vein thrombosis; PE=pulmonary embolism; COPD=chronic obstructive pulmonary disease

Table 2

Fit statistics of hierarchical logistic models predicting vena cava filter use

	Model 1: Random effects only	Model 1 + *level 1* fixed effects	Model 1 + *level-2* fixed effects	Full model: Model 1 + *level 1* and *level-2* fixed effects [a]	Cancer model [b]
Intercept (SE)	−2.70 (0.09)	−5.76 (0.18)	−3.38 (0.20)	−6.50 (0.26)	−7.10 (0.86)
Hospital random effects, τ (SE)	0.45 (0.10)	0.48 (0.11)	0.22 (0.05)	0.25 (0.06)	0.12 (0.04)
ICC[c]	12.0%	12.7%	6.4%	7.1%	3.5%
C-statistic	0.62	0.81	0.62	0.81	0.81
AIC[d]	50326.46	42570.91	50301.07	42548.15	–
BIC[d]	50330.61	42670.58	50315.61	42658.19	–

[a] Level 1 fixed effects are patient level fixed effects including all demographic and clinical characteristics. Level-2 fixed effects are hospital characteristics.

[b] Cancer only model included only individuals with cancer and the individual sites of cancer (Table 4). Fit statistics are not included since it was not compared to other models.

[c] Intraclass correlation coefficient: The proportion of the model variance explained by the "hospital" parameter; e.g. 12.0% of the Model 1 variance is explained by the hospital where a person is discharged. Calculated by $\tau/\tau+3.29$ for a binary logit model. All ICC values between hospitals were significant at $p<0.001$.

[d] Akaike information criterion and Bayesian information criterion fit statistics for comparison between models. Each measures the model fit but penalizes for additional parameters added to each model. Smaller values are preferred; thus, the full model is preferred over Model 1.

Table 3

Hierarchical logistic regression results of patient characteristics associated with use of vena cava filters

Variable		aOR	95% CI	
Age	21–25	Ref.	Ref.	Ref.
	26–30	1.12	0.80	1.56
	31–35	1.14	0.82	1.57
	36–40	1.25	0.92	1.70
	41–45	1.25	0.93	1.69
	46–50	1.38	1.04	1.84
	51–55	1.55	1.17	2.06
	56–60	1.57	1.19	2.08
	61–65	1.74	1.32	2.30
	66–70	2.00	1.51	2.65
	71–75	1.99	1.50	2.64
	76-80	2.11	1.59	2.79
	81+	2.18	1.65	2.88
Gender	Female	Ref.	Ref.	Ref.
	Male	1.05	1.00	1.10
Race	White	Ref.	Ref.	Ref.
	Black	0.83	0.75	0.92
	Other	1.13	0.95	1.35
Insurance	Other/self-pay	Ref.	Ref.	Ref.
	Medicaid	1.01	0.85	1.19
	Medicare	1.05	0.96	1.15
	Commercial	1.25	1.15	1.36
Clot type	DVT only	Ref.	Ref.	Ref.
	PE only	3.84	3.46	4.25
	PE with DVT	2.73	2.57	2.90
Comorbidities	Cancer	1.27	1.18	1.38
	Metastatic cancer	1.28	1.16	1.41
	Heart failure	1.01	0.94	1.08
	Liver disease	1.23	1.09	1.38
	Renal disease	0.94	0.88	1.00
	Diabetes	1.03	0.97	1.09
	Stroke	1.53	1.40	1.67
	Hypertension	1.02	0.96	1.08
	Hyperlipidemia	0.95	0.90	1.00
	Atrial Fibrillation	1.24	1.15	1.33
	Cellulitis	0.78	0.70	0.87
	COPD	1.03	0.98	1.09

Variable		aOR	95% CI	
	Sepsis/Septic shock	1.00	0.90	1.10
	Infection/Pneumonia	1.03	0.97	1.10
	Anemia	1.58	1.50	1.67
	Myocardial infarction	0.99	0.91	1.08
	Trauma	1.62	1.46	1.81
	Thrombolytic therapy	2.32	2.06	2.61
	Embolectomy	1.51	1.11	2.05
	Unstable/ventilator	1.37	1.21	1.55
	Proximal DVT	1.54	1.45	1.63
	Lower DVT	6.49	5.92	7.11
	Bleeding	2.72	2.51	2.94
	Surgery	1.84	1.72	1.96
Discharged	Deceased	0.63	0.56	0.70
	Transfer	0.89	0.74	1.06
Metropolitan status	Rural	Ref.	Ref.	Ref.
	Urban	0.87	0.62	1.23
Teaching status	Non-teaching	Ref.	Ref.	Ref.
	Teaching	1.46	1.04	2.06
Bed size	≤75 beds	Ref.	Ref.	Ref.
	76–135 beds	1.41	0.85	2.32
	136–275 beds	2.41	1.48	3.91
	≥276 beds	3.06	1.77	5.29

Abbreviations: aOR=adjusted odds ratio; CI=confidence interval; VCF=vena cava filter; DVT=deep vein thrombosis; PE=pulmonary embolism; COPD=chronic obstructive pulmonary disease

Med Care. Author manuscript; available in PMC 2018 January 01.

Table 4

Association between vena cava filter use and cancer site (N=13,104)

Cancer site	Total N	% using VCF	aOR[a]	95% CI	
Oral	146	8.2%	0.67	0.35	1.30
Skin	180	13.9%	1.06	0.66	1.73
Bone/soft tissue	167	11.4%	0.90	0.52	1.56
Stomach/small intestine	313	16.3%	1.17	0.80	1.70
Colorectal	1,392	16.2%	1.25	0.99	1.57
Liver	217	9.2%	0.85	0.50	1.45
Pancreas	796	11.2%	0.76	0.57	1.03
Lung/larynx/pleura	3,931	11.4%	1.02	0.83	1.25
Breast	776	7.6%	0.65	0.47	0.91
Uterus	312	15.1%	1.02	0.69	1.49
Cervix	165	17.0%	1.37	0.84	2.22
Ovarian	468	14.7%	1.13	0.81	1.58
Prostate	613	14.2%	0.98	0.72	1.32
Testicular	61	13.1%	1.62	0.66	3.95
Bladder	360	15.6%	1.12	0.79	1.58
Kidney	476	11.3%	1.09	0.76	1.55
Brain	308	24.4%	2.31	1.65	3.23
Thyroid	44	18.2%	1.22	0.46	3.24
Myeloma	378	12.2%	0.96	0.66	1.39
Leukemia	766	7.0%	0.64	0.46	0.90
Lymphoma	293	7.2%	0.76	0.46	1.26
Endocrine	121	14.0%	0.92	0.31	2.75
Metastatic	7,046	13.6%	1.13	1.00	1.29

[a]Cancer-specific regression model included all covariates from the primary model. Results for those variables were not meaningfully different and are excluded here for brevity.

Abbreviations: aOR=adjusted odds ratio; CI=confidence interval; VCF=vena cava filter